THE

ELECTRICAL REVIEW.

VOL. XXXIV. JANUARY 12, 1894. No. 842

CONTENTS:

	PAGE
Explosions in Electric Light Culverts	25
Some Lessons from the World's Fair	26
More Light on Electric Traction (*concluded*)	28
The Dying out of Alternating Current Waves	30
Rectifiers and Arc Lamp Circuits	30
A New System of Lighting and Extinguishing Street Gas Lamps without the Use of Wires (*illustrated*)	31
Town Lighting	32
American Electro-Therapeutic Association	34
Electric Lighting at Newport	35
Correspondence:—	
Professors and Consulting Engineers	37
Electric Lighting at Leicester	37
Business Notices	37
Contracts Open and Closed	40
Notes	41
City Notes:—	
The National Electric Supply Company	45
Company of the Place Clichy Sector, Paris	45
Allgemeine Elektricitäts Gesellschaft	45
Traffic Receipts	45
Share List of Electrical Companies	46
A Dynamical Theory of the Electric and Luminiferous Medium (*illustrated*) (*continued*)	47
The Novak Incandescent Lamp Case	48
The Junior Engineering Society	50
The Société Internationale des Electriciens, Paris	51
New Patents	51
Abstracts of Published Specifications	51

THE
UNIVERSAL ELECTRICAL DIRECTORY
(J. A. BERLY'S).
ORDER AT ONCE

PRICE 4/- POST FREE.
The Leading Electrical Trades Directory and the Oldest Electrical Directory in the World.

FOR THE 1894 ISSUE.

PRICE 4/- POST FREE.
Fully Revised and Thoroughly Reliable.
Contains a larger amount of commercial Trade Matter than any other Electrical Directory.

H. ALABASTER, GATEHOUSE & CO.,
22, Paternoster Row, London, E.C.

THE ELECTRICAL REVIEW.

Published every FRIDAY, Price 4d.

The Oldest Weekly Electrical Paper. Established 1872.

TO BE OBTAINED BY ORDER FROM ANY NEWSAGENT IN TOWN OR COUNTRY.

OFFICE:—22, PATERNOSTER ROW, LONDON.

Telegraphic Address "AGHEKAY, LONDON." Code A B C. Telephone No. 517

ALL Letters should be addressed to the Proprietors, H. Alabaster, Gatehouse & Co.

ADVERTISEMENT RATES ON APPLICATION.

The "Electrical Review" is the recognised medium of the Electrical Trades.

SUBSCRIPTION RATES.—In *Great Britain*, Post Free, per Year, 19s. 6d. To all *Foreign Countries* (except those mentioned below), per Year, £1 1s. 8d. *Exceptions.*—Abyssinia, Aden, Borneo, Ceylon, India, Java, Labuan, Mosambique, Penang, Persia (*viâ* Brindisi), Phillipine Islands, Singapore, Zanzibar, to which the rates are: per Year, £1 8s. 10d.

BINDING.—Subscribers' numbers bound, including case, for 3s. 6d. each volume.

CASES.—Cloth Cases for Binding can be had, price 2s. 6d. each.

READING CASES, to hold from One to Twenty-six Numbers until the Volume is complete for Binding, can now be had from the Publishers, Price 6s., or Free by Post (in Great Britain), 6s. 6d.

FOREIGN AGENTS.—New York: D. VAN NOSTRAND, 23, Murray Street. *Paris:* VEUVE J. BOYVEAU, 23, Rue de la Banque. *Berlin:* ASHER & Co., 5, Unter den Linden.

Cheques and Postal Orders (on Chief Office, London) to be made payable to Mr. H. ALABASTER, 22, Paternoster Row, E.C.

EXPLOSIONS IN ELECTRIC LIGHT CULVERTS.

IT was scarcely to be expected that the necessity for a full inquiry into questions relating to electric mains, advocated in our article of November 24th, would so quickly receive a pointed illustration. The unfortunate explosions in the Glasgow conduits, culminating on December 29th in an accident in which three men were injured, have created a feeling of great uneasiness. Within the short space of about six weeks preceding December 29th, there were at least four serious explosions. The first two of these occurred as a pair; one happening in Main Street at about 5 o'clock on one afternoon, and the second in Bath Street at about 10 o'clock next morning. It was the last of these which was referred to in the very remarkable letter of Prof. Kennedy, which appeared in our issue of December 1st.

The third explosion took place in Renfield Street on the 26th; and on the 29th the light in one side of the General Post Office at Glasgow went out. Messengers had to be sent in all directions to collect enough candles to enable the unusually heavy work of letter sorting to be carried on; and when an engineer and his assistants arrived from the electric light works to find the defect, they opened a manhole—unfortunately, with naked light near—and a severe explosion was the result; the young engineer and two of his men being injured.

This explosion was, as Prof. Kennedy would say, "due to the" use of naked lights. He has explained what the Bath Street explosion was "due to." The Main Street and Renfield Street explosions have not been publicly explained.

The most important question, however, remains. It is quite certain now that these explosions were due to the presence of house-gas in the conduits. How did it get there? The infiltration theory has always seemed to us too absurd to be for a moment tenable; and hence we were driven to look for other explanations. If anyone will take the trouble to estimate, or to think, how an *explosive* mixture could possibly be formed in a space like an electric light culvert by *infiltration* from the neighbouring soil, he will easily see that the cause is altogether inadequate. Besides, gas managers know thoroughly well, by long experince, all about gas leakage. It is well known that a large amount of gas is lost by leakage; but it is also well known that the leakage is not of the sort which would be required to form an explosive mixture in an electric light conduit.

In the case of the Glasgow explosions, the gas came direct into the culverts from severance of the gas service pipes; that is, the iron pipes which are taken off from the mains to supply the buildings on each side of the street. How the culverts came into contact with the gas pipes requires to be explained. There seems nothing more probable than the supposition of our article of November 24th, that subsidence of the soil below the troughs has taken place. If so, the

first firm support which the troughs could reach would be the gas or water service pipes, crossing the line of the troughs at right angles. With the troughs resting on the gas pipes, either of two things could easily occur; further subsidence of the supporting soil could simply break through the service pipes; or if the strip should commence buckling within the culvert and the current earth itself, the gas service pipe could be burned through.

That buckling of the strip within the Glasgow culverts has taken place is certain. We understand that expansion joints are now being introduced at the junction boxes, and certainly this is an important step to take. Another great defect in the Glasgow culverts is, that the several 4 feet 6 inch lengths of the iron tubes are not properly connected together electrically. If they were properly connected, the whole outside casing would be one vast earth plate. Any mischance to the strip inside would of course be felt at the station; but there would be no danger of the current earthing itself locally through gas pipes, water pipes, Post Office tubes, or whatever may be handiest.

Another mistake made in Glasgow was the dragging of the potential leads, not properly protected with armouring, through cast-iron pipes. The trouble which these potential leads have given was referred to in a local paper by Mr. Arnot some time ago, with the remark that Prof. Kennedy was trying to find a remedy. To anyone who has looked through a dozen cast-iron pipes, the result of drawing in unprotected, or not properly protected, insulated wire might, we think, have been foreseen. The remedy is easy to find, and the injured leads will simply need to be replaced.

That these difficulties and dangers have arisen in the installation provided for "the second city of the Empire—the city of engineers—simply *proves* the necessity for an enquiry, such as we have advocated, with the whole question of electric light mains. We think, now, that nothing short of a public enquiry under the Board of Trade will be satisfactory.

SOME LESSONS FROM THE WORLD'S FAIR.

The great American Exhibition at Chicago is now a thing of the past. As a whole, it has been in some ways a success. Like most American affairs, it was designed to be the biggest show on earth; the buildings were the biggest ever before put up at any exhibition, and the biggest fire happened in one of them; the grounds were the most extensive ever laid out for an exhibition; the situation of the show was on the edge of one of the mightiest fresh water lakes in the world; the attendance was the largest on record on July 4th.

The Ferris wheel, shown in motion, 250 feet in diameter, was the biggest wheel on earth; as a piece of mechanical construction, it was designed to rival the Eiffel Tower. Visitors were carried round in carriages suspended on the periphery, and as the speed of motion was slow, a fine changing view of the Exhibition and grounds could be obtained while being carried round.

The show made by foreigners was not large, and was principally in the arts and manufactures building; this was an immense edifice, on the top of which the biggest search light was worked.

The Exhibition in all other departments was essentially U.S.A. In the electricity building the exhibits were principally American. Among the foreigners, the Germans made by far the largest collections of their specialities. We anticipated a very large and interesting exhibition in electrical engineering appliances and inventions, and sent out a Special Commissioner to report to us the fullest accounts of the novelties, and descriptions of the machinery shown, which might not have before been described.

We were disappointed in our expectations of the Exhibition in the electricity department, and so must have been the exhibition authorities themselves. Our Commissioner reported that much of the space in the electricity building was either empty or occupied by exhibits not connected in any way whatever with electrical science or art. The big American electrical manufacturing companies had been allotted numerous large spaces; but these were filled up with very ordinary dynamos and motors, and other plant and apparatus, among which there was little or nothing new, interesting, or instructive to a European electrical engineer.

No doubt thousands of American visitors found the whole of them of great interest, and many who went through the electricity building never had opportunities before of closely examining the electrical machinery which has been developed during the past ten years; to those this great display of well-known apparatus was no doubt invaluable, but to a professional electrical engineer of 15 or 16 years' experience there was very little to arrest his attention. Bigness was the leading idea in the electrical exhibits of the American makers; they had the biggest number of arc and incandescent lamps, and the biggest electric railway ever before used at an exhibition. They had a big engine driving two big dynamos by two big belts 6 feet broad, and so on, everything being of the "All very fine and large" order. Only in one thing it was not big, and that was as an exhibition of the science and art of electricity and electrical engineering. This, of course, from a European point of view. We have had so many exhibitions, and have the earliest possible information regarding new departures or new inventions, that it is not to be wondered at that so little of real interest to the profession could be gleaned at Chicago.

In America the case is different; this show has, for the first time, brought the advanced state of electric lighting and electric power before the notice of thousands who, prior to their visit, had only dim notions of the various developments: its educational effect on the public must have been immense, and for a long time to come the impulse it has given to business will be felt; this benefit would have been immensely greater but for the unfortunate depression in trade existing in America during the run of the show, and still hanging over business there, for despite the great display of the largest company in America, its shares fell immensely in value during the Exhibition period.

British manufacturers did not exhibit largely; in fact, only two or three put in an appearance. The Willans high speed engine was introduced by an American firm of manufacturers. The high protective tariff on manufactures render trade impossible in America by British traders, and

as the visitors would be mostly American, the inducements to exhibit were very slender. This high protective tariff is, however, perhaps a blessing in disguise, from the point of view of the British workman. It effectually keeps out the manufactures of the Americans from the markets on this side. The tariff maintains high wages and high prices on materials; so much so, that other things being equal, it is impossible to sell American made electrical machinery at a price to compete with the home made article. The freight has not much influence on this question, for it is really cheaper to ship machinery from America to London or Liverpool, than to send it from London to some other parts of England or Scotland.

Many American electrical goods are suitable only for American conditions of working; this more especially in tramway and railway work. The trolley wire is everywhere used in America; it just suits them. There is no great expense or trouble in its erection and working; it forms a good enough connection to the car, and that is all there is to consider in the matter. It is altogether different in old towns and cities where many rights and interests exist, all of which must be respected, not to speak of the prejudice against erections in public thoroughfares.

And so with the American universal arc lamp plants; every town and village has its arc lights. In most cases the circuits are strung up overhead from house to house, using poles where no other supports come in, and in some cases the whole circuits are carried through a town on poles. This practice has never obtained a footing in any other country in the world, and is never likely to be instituted in Great Britain.

The electrical industries in America have for some time been suffering from severe competition; it has been overdone. There is not employment for all the capital and hands now engaged in it; the growth of companies and traders has been more rapid than the growth of the business, hence the present check.

The utilisation of water power in America promises to be a big business. Waterfalls abound over there. The Pelton water wheel is a wheel much used in this line of work; it is purely an American development. A good example of it was shown at Chicago by the General Electric Company, working in a glass sided casing. It is the simplest of wheels, and has only one drawback from our point of view; that is, it must be placed at the lowest point in the waterfall. This, of course, applies to many other wheels.

In telephone apparatus, American manufacturers have established a good business in every country in the world. This is due principally to the adoption of machinery of a very perfect nature for the construction of the parts, thus doing away with hand labour as much as possible. In this line the Western Electric Company had a magnificent show; their works at Chicago are very extensive and of great interest to telephone men.

We have published everything of interest coming from the Exhibition. Our Special Commissioner's articles were profusely illustrated, and show every novelty to be seen in July. At that date many of the exhibits were not *in situ*, and some were covered up, being put in order. There was also insufficient attendance on the exhibits; and at some stalls circulars and illustrations could be got only by leaving one's address, so that they would be posted if one were considered good for business. These, and other little devices peculiar to some American traders, exhibited the prevailing fear lest they should "give themselves away," as they say.

From a European point of view, the electrical exhibits were of little or no interest, and therefore, as an Exhibition, we consider it was a failure.

The Blackening of Incandescent Lamps.

WE publish in other columns of this issue an abstract of a lamp case which is proceeding in America, a perusal of which will be found interesting. Mr. Edison has made an affidavit which deals at some length with the subject of lamp blackening and the disintegration of filaments, and his observations form a welcome contribution on this important topic. With all deference to Mr. Edison's views, he seems to ignore the physical law regarding the vapourisation of bodies in general. This law was concisely and forcibly stated in an article on lamp blackening, by Mr. Stuart Smith, which appeared in our issue for December 15th last. The phenomenon of lamp blackening in ordinary high vacuum lamps is one which is, or at any rate may be, complicated by various conditions and circumstances, such as the manner of flashing the filaments, but, as Mr. Smith says, one of the causes *must* be due to direct and simple vapourisation of carbon. It is worth while to reiterate the well known fact that filaments which have been flashed do not tend to blacken the bulbs nearly so much as those not so treated. Further, it is a fact that filaments heavily flashed, under conditions not necessary to relate, cause less blackening than do filaments less heavily treated. These considerations would suggest that the blackening of lamps is largely dependent upon the surface area of the carbon to which the residual gases have access. All forms of amorphous carbon are extremely porous, and, consequently, have an enormous extent of surface, far exceeding the cubical area of the mass, and there can be little doubt that carbon vapour forms on the internal surfaces of a very porous carbon as well as on the outward and visible portion. And since the carbon obtained in the flashing process is much more compact than that of the foundation, which is usually baked cellulose or silk, it is reasonable to conclude that there is a less extent of carbon surface visible, so to speak, to gases, and from which volatilisation can proceed. Mr. Edison seems to imagine, from the circumstance of his being unable to detect any diminution in the size of filaments taken from blackened lamps, that were carbon to volatilise it would come only from the external surface, and hence be measurable, but, according to the view put forward, it might well be impossible to measure the diminution, especially if the observations were conducted with untreated bamboo filaments. In connection with the flashing process the Edison Company is to be congratulated in having at length commenced its adoption; though its motives—see Mr. Edison's affidavit—for having refrained so long from doing so, are to be greatly respected. It is a little mysterious, however, why the company did not employ it in early days, and prior to the granting of Weston's patent in 1884. The process was in common use from the earliest days of lamp manufacture.

More Light on Electric Traction.

IT must be admitted that Mr. Epstein makes out an exceedingly good case for accumulator traction in the contribution which is concluded this week. At the same time he cannot be accused of undue desire to put accumulators in a favourable light. The figures which he has compiled have been collected with the greatest care and tabulated with great fairness. The tables which have been prepared for the article are of considerable value, in fact, we venture to say that comparisons so exhaustive have never been made before. The estimated cost of working overhead and accumulator systems show that while the actual cost of working is slightly in favour of the overhead, complete costs are nearly equal, this being due to the interest on less capital. It is difficult to take exception to any of the items, except that the maintenance of roads might be a little higher in the case of accumulators than Mr. Epstein has allowed, due to the heavier cars, but it is a matter that would not much affect the total cost. In the construction and equipment of lines the accumulator system is much cheaper; even with a short headway service, where it might have been expected that accumulators would have been expensive, the overhead wire system is much dearer. In the conversion of an existing horse tramway to an electric system, accumulators show decided advantages.

MORE LIGHT ON ELECTRIC TRACTION.

By L. EPSTEIN.

(*Concluded from page* 21.)

Cost of Fuel.

O., U.—It has been found that on a line, the conditions of which may be considered as fairly representative, that is to say, on which there are several gradients, but none exceeding 1 in 25 for a short distance, 80 watt hours are required to be put into the motors per ton mile propelled.

Now, assuming the efficiency of the line to be 75 per cent., and the efficiency of the dynamos under the varying load to be 80 per cent., this corresponds to 133 watt hours from the dynamos at the station per ton mile, and further assuming an efficiency of the steam engines and belting of 75 per cent., equalling an output of 560 watts per I.H.P., we find that the above 133 watt hours necessitate an output of ·24 I.H.P. hours per ton mile propelled.

Taking the weight of a 40-passenger car, with motor and gearing and the full complement of passengers at 8 tons, this corresponds to 1·92 H.P. hours per car mile, and at a consumption of 3 lbs. of good coal per I.H.P. hour, at a cost of 20s. per ton, the price of fuel per car mile will be ·617d.

The 80 watt-hours to be supplied per ton mile from the accumulator batteries, at an efficiency of these latter of 75 per cent., necessitate an expenditure from the dynamos at the charging station of 106·66 watt-hours per ton-mile.

As the engines and dynamos will be worked at a uniform rate, and near their maximum output, their combined effici-

TABLE IV.

OVERHEAD SYSTEM.—Cost of conversion of an existing horse tramway into an electric tramway. Line 6 miles long, double track, cars for 40 passengers. It is assumed that the existing permanent way may be used for the heavier electric cars.

		10 mins. headway: 12 cars.	5 mins. headway: 24 cars.	2½ mins. headway: 48 cars.
1.	Overhead system and electric ground work at £900 per mile of double track	£5,400	£5,400	£5,400
2.	Feeders and erection:—			
	Bare wire at £1,000 per mile of double track	6,000	Bare wire at £2,000 per mile 12,000	Bare wire at £4,000 per mile 24,000
	If insulated wire at £1,700 per mile of double track	(10,200)	If insulated wire at £3,000 per mile (18,000)	If insulated wire at £5,600 per mile 33,600
3.	Cars, trucks, motors, and gearing, at £410 per car	4,920	24 cars 9,840	48 cars 19,680
4.	Boilers and engines for 380 I.H.P., with reserve, at the rate of £8 per I.H.P.	3,040	760 I.H.P. with reserve 6,080	For 1,520 I.H.P. with reserve 12,160
5.	Dynamos for 230 units with reserve, at the rate of £7 per unit	1,610	460 units with reserve 3,220	920 units with reserve 6,440
	With bare wire for feeders	£20,970	£36,540	£67,680
	Per car	£1,747	£1,522	£1,410
	„ mile of double track	£3,495	£6,090	£11,280
	With insulated wire for feeders	£23,170	£42,540	£77,280
	Per car	£2,097	£1,772	£1,610
	„ mile of double track	£4,195	£7,090	£12,880

UNDERGROUND SYSTEM.—The cost of the culverts, including the necessary alteration to the road, will be found to be about £4,000 per mile of double track (as compared with £900 per mile for the overhead system), and the cost of feeders approximately the same as the insulated wires of the overhead system. The cost of cars, steam, and electric plant, the same as above.

Total cost	£43,770	£61,140	£95,280
Per car	£3,647	£2,547	£1,997
„ mile of double track	£7,295	£10,190	£15,980

TABLE V.

ACCUMULATOR SYSTEM.—Cost of conversion of an existing horse tramway into an electric tramway. Line 6 miles long, double track. Cars for 40 passengers. It is assumed that the existing permanent way may be used for the heavier electric cars.

		10 mins. headway: 12 cars.	5 mins. headway: 24 cars.	2½ mins. headway 48 cars.
1.	Cars, trucks, motors and gearing, at £410 per car	£4,920	24 cars £9,840	48 cars £19,680
2.	Boilers, engines, for 260 I.H.P., with reserve, at the rate of £8 per I.H.P.	2,080	For 520 I.H.P. 4,160	For 1,040 I.H.P. 8,320
3.	Dynamos for 180 units with reserve, at the rate of £7 per unit	1,260	For 360 units 2,520	For 720 units 5,040
4.	* Accumulators, 2½ sets, of 72 Epstein cells, type T 7 = 180 cells per car at £2 £360			
	Trays, connections, &c., at £40 per car 40			
	12 cars at £400	4,800	For 24 cars... 9,600	For 48 cars... 19,200
5.	Elevators, acid tanks, pumps, &c., at £120 per car	1,440	At £100 per car 2,400	At £100 per car 4,800
	Total cost	£14,500	£28,520	£57,040
	Per car	1,208	£1,188	£1,188
	„ mile of double track	£2,417	£4,753	£9,507

* 5 sets divided between 2 cars.

Table VI.—Summary.

(1) Cost of construction and equipment of a line 6 miles long, double track.

	10 minutes headway: 12 cars.			5 minutes headway: 24 cars.			2½ minutes headway. 48 cars.		
	Total cost.	Cost per car.	Cost per mile of double track.	Total cost.	Cost per car.	Cost per mile of double track.	Total cost.	Cost per car.	Cost per mile of double track.
Overhead, bare feeders ...	£87,570	£7,300	£14,595	£103,740	£4,322	£17,290	£136,080	£2,835	£22,680
„ insulated feeders ...	91,770	7,647	15,295	109,740	4,572	18,290	145,680	3,297	26,380
Underground	104,370	8,697	17,395	122,340	5,097	20,390	158,280	3,297	26,380
Accumulators	81,100	6.758	13,517	95,720	3,988	15.953	125,440	2,613	20,907

(2) Cost of conversion of an existing horse tramway 6 miles long, double track, into an electric tramway.

	10 minutes headway: 12 cars.			5 minutes headway: 24 cars.			2½ minutes headway: 48 cars.		
	Total cost.	Cost per car.	Cost per mile of double track.	Total cost.	Cost per car.	Cost per mile of double track.	Total cost.	Cost per car.	Cost per mile of double track.
Overhead, bare feeders ...	£20,970	£1,747	£3,495	£36,540	£1,522	£6,090	£67,680	£1,410	£11,280
„ insulated feeders ...	25,170	2,097	4,195	42,540	1,772	7,090	77,280	1,610	12,880
Underground	43,770	3,647	7,295	61,140	2,547	10,190	95,880	1,997	15,980
Accumulators	14,500	1,208	2,417	28,520	1,188	4,753	57,040	1,188	9,507

Table VII.

From Readings taken by the Epstein Accumulator Company on the lines of the Birmingham Central Tramway Company. 96 Epstein Accumulators. Weight of car with passengers = 12 tons. Length of line = 3 miles

No. of test.	Date of test.	Total expenditure from battery.			Watt hours from terminals of battery per ton-mile.	Average expenditure from battery.				Watts from terminals of battery per ton average.	Maximum expenditure from battery.			Watts from terminals of battery per ton maximum.	Average running speed, miles per hour.	Route to Bournbrook Town.
		Amp. hours.	Watt hours.	E.H.P. hours.		Volts.	Amps.	Watts.	E.H.P.		Amps.	Watts.	E.H.P.			
	1892.															
1	Dec. 21	32	3,015	4·04	84	93	94	8,742	11·72	728	190	23,180	31·07	1,932	6·5	B. to T.
2	„ 22	29	2,881	3 86	80	99	97	9,603	12·87	800	160	20,480	27·45	1,707	7	„ „ „
3	„ „	28	2,902	3·89	80·6	104	98	10,192	13·66	850	158	20,224	27·11	1,685	7 7	T. „ B.
4	„ „	31·5	3,370	4 52	93·6	107	105	11,235	15·06	936	160	19,840	26·60	1,653	6 8	B. „ T.
5	„ „	31·5	3,232	4·33	90	102	100	10,200	13 67	850	164	19,680	26 38	1,640	7·3	T. „ B.
6	„ „	31·5	2,884	3·87	80	100	101	10,100	13·53	841	150	18,750	25·13	1,562	6·9	B. „ T.
7	„ „	31·5	3,660	4·90	102	74	97	7,178	9·62	598	160	16,640	22·30	1,387	5·9	T. „ B.
	1893.															
8	Jan. 6	31·7	3,084	4·13	86	97·4	100·2	9,739	13·05	811	158	21,488	28·80	1,790	7·5	B. „ T.*
9	„ „	44·13	3,829	5·13	106	86·8	105·2	9,131	12·24	761	210	26,040	34·90	2,170	6·47	T. „ B.
10	„ „	34	3,623	4·85	101	105·5	112·4	11,858	15·90	988	170	22,100	29·62	1,841	7·45	B. „ T.
11	„ „	44·64	4,579	6·14	127	102·5	115·7	11,859	15·90	988	180	21,600	28·95	1,800	6·8	T. „ B.
12	May 17	25·3	2,600	3·49	72	101·6	94	9,650	12 93	804	160	20,480	27·45	1,707	7·5	B. „ T.
13	„ „	22·4	2,064	2·77	57	92·3	83	7,661	10·27	638	138	17,388	23·31	1,449	7 7	T. „ B.†
14	June 29 (72 cells)	26·5	2,733	3·66	101	103·3	89·2	9,214	12·35	1,024	150	18,900	25·33	2,100	7·88	B. „ T.‡

* During a snowstorm. † Rails in excellent condition. ‡ 72 cells, weight total 9 tons.

ency may be estimated at about 80 per cent., or 600 watts per I.H.P., so that the above 106·66 watt-hours will correspond to an expenditure of ·177 I.H.P. hours per ton-mile propelled.

Taking the weight of a 40-passenger car with motor and gearing, full complement of passengers and accumulators as 10 tons, this corresponds to 1·77 H.P. hours per car mile, and at a consumption of 3 lbs. of good coal per I.H.P. hours, at a cost of 20s. per ton, the price of fuel per car mile is ·57d.

It will, therefore, be seen that notwithstanding the increased weight of the accumulator car, the consumption of fuel is less than in the case of the direct system of conveying the current.

N.B.—Whoever has watched the progress of a trolley car in one of the American cities at a time when the frequent taking up and letting down of passengers necessitate stops at intervals often of a fraction of a minute, with consequent waste of energy through resistances, will find the comparison much too favourable to the direct system.

Final Conclusions.

1.—*Cost of Installation.*

By referring to the comparisons in Tables II., III., IV., and V., it will be seen that the cost of an accumulator line is less than that of the overhead or underground systems.

In round figures this saving amounts to about 20 per cent.

Table VIII.

Estimated Cost of Working.—Overhead or Underground. Cars for 40 passengers.

	Pence per car mile.		
	Lowest.	Highest.	Average.
1. *Running Expenses.*			
(*a*) Fuel	·25	·75	·50
(*b*) Oil, waste, and sundries ...	·03	·08	·05
(*c*) Brushes on motors and lubrication	·10	·30	·20
(*d*) Wages at generating station..	·20	·40	·30
(*e*) Drivers' wages	·50	1·00	·75
	1·08	2 53	1 80
2. *Maintenance of Roads*	·50	1·00	·75
3. *Repairs of Cars*	·25	·75	·50
4. *Traffic Expenses.* Wages of inspectors, cashiers, timekeepers, conductors, tickets, and miscellaneous ...	1·00	2·00	1·50
5. *General Charges.* Directors' fees, salaries, office expenses, advertisements, insurance and miscellaneous, rents, rates, taxes, &c. ...	·50	1·00	·75
6. *Depreciation and Repairs.*	1·00	2·00	1·50
Total working and general expenses	4·33	9·28	6·80
Interest on the capital invested ...	2·20	3·30	2·75
Grand total	6·53	12·58	9·55

TABLE IX.

ESTIMATED COST OF WORKING.—ACCUMULATORS.

Cars for 40 passengers.

	Pence per car mile.		
	Lowest.	Highest.	Average.
1. *Running Expenses.*			
(*a*) Fuel	·20	·60	·40
(*b*) Oil waste and sundries ...	·03	·08	·05
(*c*) Brushes on motors and lubrication	·10	·30	·20
(*d*) Wages at charging station ...	·50	1·00	·75
(*e*) Drivers' Wages	·50	1·00	·75
	1·33	2·98	2·15
2. *Maintenance of Roads*	·50	1·00	·75
3. *Repairs of Cars*	·25	·75	·50
4. *Traffic Expenses.* Wages of inspectors, cashiers, timekeepers, conductors, tickets, and miscellaneous ...	1·00	2·00	1·50
5. *General Charges.* Directors' fees, salaries, office expenses, advertisements, insurance and miscellaneous, rents, rates, taxes, &c.	·50	1·00	·75
6. *Maintenance of Accumulators* ...	·50	1·50	1·00
7. *Depreciation and Repairs*	·50	1·00	·75
Total working and general expenses	4·58	10·23	7·40
Interest on capital invested ...	1·77	2·64	2·20
Grand total	6·35	12·87	9·60

In the case of the conversion of an existing horse tramway, the balance is still more in favour of the accumulator system, the outlay being only about one-half of the overhead system, or one-third of the underground system.

2.—*Cost of Working.*

On referring to Tables VIII. and IX., it will be seen that the cost of working is approximately the same with any of the systems under consideration.

3.—*Mode of Operation.*

Apart from the necessity of providing a larger plant at the generating station, the direct systems have the further disadvantage that the almost incessant variation of the load throws a heavy strain upon the machinery, and increases the cost of maintenance.

Besides, as the engines must at any time be prepared to take their maximum load, steam must generally be kept up, and coal consumed, whether this steam is required or not.

On the other hand, the accumulator car being self-contained, will accommodate itself to any variations in the power required, without reacting direct upon the generating plant, which it will be possible to work at a uniform rate, and near its maximum output.

Again, even with a reserve plant at the station, in case of heavy temporary stress, some cars on the direct system will not be so efficiently supplied with current as the self-contained car, which has at its own disposal a large store of energy.

There are other advantages appertaining to a system of self-contained cars which, however, are too well known to require reiteration here.

THE DYING OUT OF ALTERNATING CURRENT WAVES.*†

BY A. E. KENNELLY.

IT has been asked how many times an alternating current could be transformed through successive induction coils without losing its essential wave character.

If the induction coils have no iron cores, the case depends entirely upon the shape of the wave of E.M.F. impressed at the terminals of the first transformer. Supposing that this wave were sinusoidal, then after the permanent state of steady activity had been attained, all the currents and voltages throughout the series would be sinusoidal. There would be attenuation, and change of phase along the series, but there would be no change of wave type, whatever the resistances, capacities, or inductances might be, provided these did not vary with time.

If the wave of E.M.F. impressed upon the first transformer were not sinusoidal, then, with iron still excluded, there would be a progressive change of wave type accompanying the attenuation and phase displacement. The change would be rapid in the earlier, and more gradual in the more remote transformers. The finally surviving waves after an indefinitely great number of successive conversions, would be fundamental sinusoids, *i.e.*, simple harmonic waves of the alternation frequency. The exact rate at which deviations from the sinusoid are absorbed depends upon all the conditions of the successive circuits, but is open to computation when these data and the initial wave outline are forthcoming.

If, on the other hand, the induction coils contain iron, new considerations arise. There will now be hysteresis and variable magnetic leakage to take into account. Owing to hysteresis the currents will not be sinusoidal, even if the first impressed E.M.F. be sinusoidal, and owing to this the drop of pressure in resistances will introduce a departure in the voltages from the simple harmonic type. The magnetic leakage which varies during the cycle also causes some deviation of a similar nature. But while this disintegrating influence is extending there will also be a correcting tendency at work such as would be established by transformers without iron. Which of these tendencies will preponderate, whether the waves would become more and more distorted along the series, or more nearly sinusoidal, would depend upon all the circumstances of the circuits, of the quality of iron in the cores, and of the initial wave outline, but under ordinary conditions it would seem that the waves would never become truly sinusoidal, but would also never undergo great distortion.

Briefly, then, non-ferric induction coils would, in the permanent state, transmit an initial sinusoidal wave through an indefinitely long series of such coils, unchanged in type. They would also sift an initially non-sinusoidal wave down to a sinusoid, so that practically the conditions might then be closely represented by a sinusoidal generator of reduced amplitude brought into operation further along the line, beyond the principal sphere of shifting action. With ferric transformers the case would be more complex, but broadly, there would be a tendency for the sinusoid to survive.

* See the *Electrical Engineer*, December 6th, p. 497.

† New York *Electrical Engineer*.

"RECTIFIERS" AND ARC LAMP CIRCUITS.

BY RANKIN KENNEDY.

MANY have been the proposals made for the construction of an apparatus for turning alternating currents into continuous currents; ever since the introduction of the alternating system this has been a favourite pursuit for inventors. Continuous currents have for some purposes considerable advantages over alternating currents; and, in some particular operations, the current must of necessity be perfectly continuous.

For arc lamps the continuous current is undoubtedly preferable, not only on account of the better working of the lamps, but also on account of the light being better directed from a continuous current arc. For arc lamp working a current may not be perfectly continuous to secure these advantages, it is only necessary that the impulses of current should be rectified, or made unidirectional. For charging accumulators or working electromotors, where in both cases a counter-electromotive force is set up, the current, if intermittent, must be connected on to the battery or motor at a point in its rise of pressure where the pressure is at least equal to the back or counter-pressure of these apparatus, and then disconnection must again be made at a point in the fall of the pressure in the current impulse just after the counter-pressure overpowers the impressed pressure.

For the foregoing reasons it is evident that a rectifier

which would quite satisfactorily work arc lamps by turning the alternating current into a pulsatory current, rising and falling 50 times a second, perhaps, from zero to 2,000 volts, would be of no use for other purposes requiring continuous current.

A simple alternating current can easily be "rectified," so that the current impulses are sent into the external circuit always in the same direction, but such a current is never even approximately continuous; it has its alternate zero and maximum values; consequently it still sets up a humming sound in the arc, but it forms a proper crater on the positive carbon point as well as any continuous current could do.

This fluctuating current still sets up induction in metallic bodies influenced by it, but not to the same extent as the alternating current would act upon them. The old shuttle-wound Siemens armatures used in early dynamos produced one single alternating current, and this was rectified by the well-known split tube commutator, producing an intermittent current. Later on the Gramme commutator was invented, producing a continuous current perfectly smooth. Still this current is produced by rectifying a number of currents in different phases produced in the ring windings.

These methods and several modifications have recently been applied to the production of unidirection currents, both intermittent and smooth in flow; the split tube commutator rectifies a single alternating current into a pulsating current, and has been introduced for running arc lamps on alternating circuits. The commutator is driven by a synchronising alternating motor. Working arc lamps the current in series is not over 10 amperes as a rule, and the load also, as a rule, is constant; under these conditions, this pulsatory current acts fairly well, and with only some slight sparking at the brushes even at, or over, 1,000 volts.

For charging accumulators, Dr. Pollak has recently introduced a modification of the split tube commutator. He makes the slit in the tube wide, in fact the slits are as wide as the parts of tube left. By this means he gets the current only at the top of the pressure wave, and the current is actually a series of impulses sent under a pressure beginning at, say, 50 volts, rising to 70, and falling again to 50 volts, and between these intervals of current there is an equal interval of no current at all, if the alternating current curve is a sine curve, but by deforming the curve this interval of no current can be shortened in time.

Neither of these methods produce what might be called a continuous current. To accomplish the production of a continuous, or approximately continuous current by a single-phase alternating current is no easy problem; it has not been yet solved by any of the proposals made hitherto except one, and that one we are afraid is not applicable to high-pressure work, although it may, and no doubt does, good work on low pressure of, say, 100 volts. A pair of rings fitted over the commutator of a multipolar dynamo, and each ring coupled to one plate on the commutator—the plates selected must be on opposite diameters—converts an ordinary dynamo into a synchronising motor, which, if it by any means can be run up to synchronism, and be coupled to any alternating circuit by brushes resting on the two rings, will run steadily as an alternating motor, while from the ordinary brushes a perfectly steady current can be drawn continuous and smooth.

"Rectifiers" are being introduced at present principally for arc lamps in series, and by their use the troubles due to self-induction and mutual induction in the circuit are very much reduced. While the light is thrown downwards and the humming is not so loud, but still exists. These rectifiers are of the split-tube type.

A "rectifier" producing a perfectly continuous current, or even an approximately continuous current, is preferable, and would have no trouble at all with induction, either self or mutual, and would run the lamps perfectly silent. If it can also be used for low pressure and high pressure equally well, it would find a field of usefulness at once in the many alternating current supplies now working.

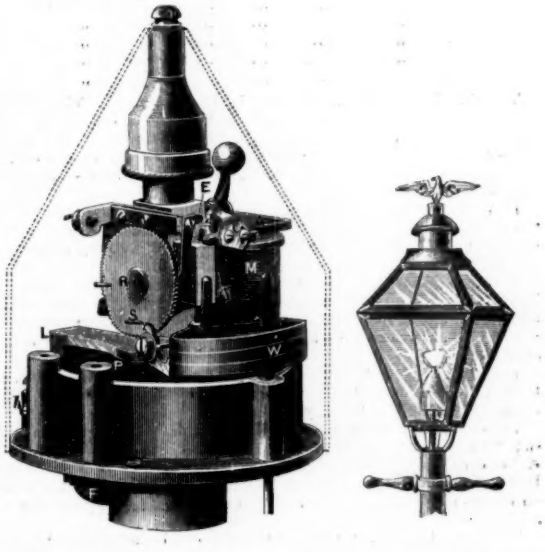
"Rectifiers" are essentially modifications of old devices, and are interesting to the student of electrical engineering. In our articles on "Electrical Distribution," we have some of the latest inventions in this art briefly described, mostly for multiphase rectifiers, but single phase rectifiers are of more immediate importance, as little or nothing has been established in this country working with multiphase currents.

As a feature in the art of arc lighting, the introduction of rectifiers on alternating circuits is very significant, as it points the moral that no one system of electricity supply can entirely fulfil all the many requirements in the application of electricity in the useful arts.

A NEW SYSTEM OF LIGHTING AND EXTINGUISHING STREET GAS LAMPS WITHOUT THE USE OF WIRES.*

AN electrical system which operates at will from a central point devices placed miles apart with no electrical connection between them has been placed on the market by the Cutler-Hammer Manufacturing Company, 247, South Jefferson Street, Chicago. The Cutler system discards the unsightly overhead wires and the expensive underground circuit, and adopts an entirely new and inexpensive method. Each lamp is supplied with two sal-ammoniac batteries, and a spark coil placed in an iron box buried in the ground at the foot of the post. In the lantern is a miniature gas holder of about two cubic inches capacity, pivoted on a hinge and held down by weights; and directly over this holder is an automatic gas lighter, similar to those used in houses, only much simpler, larger and stronger. Two wires, about 10 feet long, connect the lighter with the batteries through the post. Such an installation is under complete control from the gas works. When it is desired to light the lamps of a city, it is only necessary to open the valve connecting one of the large gas holders at the works direct with the gas mains. This results in a decided increase of pressure in the gas all over the city, sufficient to cause all the little gas holders in the lamp posts to lift up about one-eighth of an inch against a platinum stop, and thus close the local battery circuit at each post. The automatic lighter being then supplied with current, immediately turns on and lights the gas. In a word, the system is merely a huge pneumatic push button, and corresponds precisely to pushing a button, when desiring to light the gas in a house supplied with automatic lighters.

The cut shows the lighter about two-thirds full size; P is the pressure gauge or gas holder sealed with mercury and held down by the weights, W. When the gauge lifts, it



closes the electric circuit through the magnet, M: the armature, A, is attracted and caused to vibrate, throwing sparks at E and turning the ratchet wheel, R. The first movement of the ratchet wheel admits the gas to a small auxiliary outlet at E, as well as to the main burner. The electric sparks formed at E ignite the auxiliary jet, which immediately shoots up and lights the main burner. As the ratchet wheel continues to turn, the auxiliary jet is closed, leaving the main burner open. The ratchet wheel is finally stopped with the

* New York *Electrical World.*

gas turned full on and lighted, by a pin in the wheel striking against a stop, S, attached to the pressure gauge, P.

It has been shown in practice that 15 seconds is amply sufficient for maintaining this increased pressure, to give time to make the increase everywhere felt. It can then be brought back to normal pressure, when the pressure gauge, P, will drop and open the electric circuit. This operation, if repeated, will extinguish the lamps.

The mechanism of the lighter is extremely simple, and made so strong as to insure it from getting out of order or requiring attention of any kind. A heavy cast-iron shell $\frac{3}{16}$ths of an inch thick, shown by dotted lines in the cut, entirely surrounds the mechanism and thoroughly protects it from all kinds of external abuse. No part of the lighter is exposed except the lava tip, which is easily replaced should it become stopped up or broken. An outlet at P provides a passage for pouring in alcohol should the gas freeze in the riser pipe in winter. The iron battery boxes are supplied with covers flush with the ground, which are intended to be removed once a year for cleaning the batteries. This operation constitutes the entire operating expenses.

The burner used is the sub-type and gives a yellow flame without tongues and very little blue. It will consume exactly the number of cubic feet for which it is set under extremes of pressures varying from 1 to 5 inches of water.

TOWN LIGHTING.

MR. HAMMOND has submitted a report to the Corporation of the City of Wakefield, from which we abstract the following:—

There is not a wide difference between the various systems of generation of electricity, but there are many systems of distribution of electrical energy for house-to-house lighting by means of incandescent lamps.

The filaments within these lamps are made to stand only low pressure, and whatever system of generation or distribution may be adopted, the electricity must finally be delivered to the lamps at low pressure, *i.e.*, low tension.

Distribution at low tension throughout, however, involves the use of a large quantity of electricity, since the electrical energy required for lighting is the product of pressure and quantity.

For instance, 1,000 lamps, requiring each 35 watts of electrical energy, use a total of 35,000 watts, which may be brought from the generating works in the form of

Pressure.		Quantity.	
2,000	volts	17·5	ampères
1,000	„	35	„
500	„	70	„
300	„	116·6	„
100	„	350	„

The size of the mains is governed by the quantity of electricity to be conveyed, and the distance to which it has to be conveyed.

It is manifest, therefore, that distribution by means of low tension necessitates much larger mains than distribution by means of high tension, and in scattered areas the length of the mains practically prohibits low tension distribution.

In Wakefield, however, the city covers a compact area, the bulk of the lighting being embraced within a radius of half a mile from a central point. This can very easily be coped with by means of a pressure of 200 volts (three-wire system).

In order, however, to keep the size of the main within practicable limits it will be necessary to generate the electricity at high tension, and to bring it at high tension to the distributing station in the City, say at Kirkgate Corner, or at any other suitable site which may be available.

This distributing station would be in charge of an attendant, and from it the electricity would be distributed by means of cables radiating throughout the city.

The cost of a 3-inch culvert, and the cable requisite for bringing sufficient electricity from the sewage site to maintain, say, 6,500 incandescent lamps burning simultaneously, would be £1,452, the cable being of section large enough to provide for a loss of electrical energy on route of only 5½ per cent. at full load, the loss dropping down to zero as the load diminishes.

The annual monetary value of this loss can be estimated by calculating the total cost of production, and taking this at about £2,000, the 5½ per cent. would work out £110. As, however, the 5½ per cent. loss only occurs at full load, and dwindles to nothing at no load, it would be safer to take the average at 1 per cent., or say £20.

To this must be added the amount of the annual charge involved by the capital outlay.

Presuming that the city borrows at 3 per cent., and arranges to pay off the electric lighting loan in 25 years, the annual charge in respect of the above-named £1,452 would be £83 10 0
Cost of the electrical energy lost on the route estimated at 20 0 0

Total £103 10 0

which represents the annual cost of the distant site.

As a set-off against this annual charge there are many important advantages connected with the distant site.

1. It is of such a size that the city will not be compelled, as many have been, to choose cramped up and unsuitable driving engines.
2. Water will be available for condensing, the effluent sewage being probably available.
3. Coal will be obtainable at a cheaper rate than if delivery had to be made into the centre of the city.
4. Supervision of the borough officials will be facilitated by the proximity of the electricity works to the sewage works.

SIZE OF WORKS.

I have already pointed out that in coping with the problem of electricity supply, the plant can be laid down in instalments to meet the actual requirements of the city. In any case, whatever the size of the plant, it is desirable to divide it into units, as only for about half an hour daily is the full capacity of the plant required. On the other hand, too small a sub-division is undesirable, as small engines do not work so economically as large ones.

I recommend that the unit should not be smaller than 150 I.H.P., driving an alternator dealing normally with a maximum load of 75 kilowatts, *i.e.*, capable of lighting 2,500 incandescent lamps, all burning at one time, permitting the fixing of about 3,750 lamps on the premises of the consumers.

I estimate that the cost of works containing this size unit would be £12,000, which figure covers all engineering charges and a fair margin for contingencies. It includes:—

1. Suitable building, to cost with the foundations of the plant, £1,500.
2. Lancashire boilers, with feed-water heaters, and all necessary steam and exhaust pipes.
3. Horizontal slow-speed engines.
4. Alternators.
5. Switchboard.
6. Condensing arrangements.
7. 2,100 yards 3-inch cast-iron culverts.
8. 8,400 yards of well insulated high tension cables (*i.e.*, four cables of 2,100 yards each; this sub-division providing for easy manipulation, testing, and repair), to connect the generating with the distributing station, and of a size capable of carrying the electricity generated by three such plants.
9. Plant of distributing station.
10. 2,850 yards of well insulated triple concentric low tension distributing mains, with all requisite feeders for three such plants.
11. Ten arc lamps, lamp-posts, and switches.

But it must be borne in mind that the costs of working a large plant are, in the main, the same as those incurred in working a small plant, the only additional expenses of working a large plant, as compared with a small one, being that of the extra coal, and the wages of additional engine drivers and stokers, and (with mechanical stokers), up to three units of plant, there is hardly any additional wages at all. Unless, therefore, it is of vital importance to minimise the capital expenditure, it is hardly wise to limit the first works to *one* unit of plant.

The cost of two 150-I.H.P. plants, with a capacity of 5,000 lights burning at once, and, say, 7,500 lights installed, would be £15,750, including 15 arc lamps, posts, switches, &c., for public lighting, and £2,250 for the buildings, foundations, &c.

The cost of three such plants, with a capacity of 7,500 lights burning at once, or, say, 11,250 lights installed, would be £19,500, including 20 arc lamps, posts, switches, &c., for public lighting, or for letting out to tradesmen, &c., and 3,000 for the buildings, foundations, &c.

For economically dealing with the low loads between 11 p.m. and sunset the next day, I recommend the use of a small day load self-contained plant of 50 I.H.P., the cost of which, with necessary additions to switchboard, would be £650.

This sum must therefore be added to each of the foregoing estimates.

Summarising the foregoing, we have:—

	£
(A).—Plant for 2,500 lights, burning at once, or 3,750 installed, costs	12,000
(B).—Plant for 5,000 lights burning at once ...	15,750
(C).—Plant for 7,500 lights burning at once ...	19,550
(D).—Day load plant for 800 lights burning at once	650

REVENUE.

In order to arrive at a just appreciation of the probable revenue, an estimate must be made of the probable consumption of electricity in the City of Wakefield.

This can, of course, only be arrived at by comparison with other places.

The following is a statement of the consumption of electricity per lamp fixed, which obtains in some of the central electricity works already in operation:—

Name of town.	Annual consumption per lamp fixed.
Bradford	18·45
Birmingham	18·09
Brighton	19·51
Bournemouth	18·20
Exeter	19·14
Southampton	22·53
Liverpool	27·49
Northampton	10·94
Leeds (not yet ascertained, the supply having only been started in May last)	
	154·35
Average of eight places	19·29

To be well within the mark, I think that the revenue may be calculated in Wakefield on the basis of a consumption of 18 units per lamp fixed.

The next step must be to determine what percentage of lamps may be fixed in excess of the maximum which the station can produce.

In some localities it is found that out of every 100 lamps fixed, there are never more than 50 in use at any one time, and in these places it is of course quite safe to instal throughout the town just double the number of lamps which the station can produce at any one time.

In Wakefield, I gather that the bulk of the demand will come from business premises, and under these circumstances it will probably be found that out of every 100 lights fixed, 66 will be all on at one time.

Having decided that 50 per cent. more lights may be fixed than the maximum capable of being produced at the works, it will be for you to decide to what extent you will provide for reserve plant.

Plans.	Normal.			
	Capacity in horse-power.	Capacity in kilowatts.	Capacity with lights all on at once.	Permitting of fixing 50 % in excess.
A + D	200	100	3,300	4,950
B + D	350	175	5,800	8,700
C + D	500	250	8,300	12,450

If, however, all the above lights were fixed, there would be absolutely no margin of reserve. On the other hand, it must be borne in mind that the time of top load only lasts for about half an hour daily, and the risk involved in running the plant to its full capacity during half an hour daily is only very slight, and as the plant which I have specified is of first class quality there would be a minimum risk of breakdown, especially as the plants could, in an emergency, be run with ease fully 20 per cent. beyond their normal capacity.

According to the number of plants, the following would be the revenue on the basis of the consumption of 18 units per lamp, per annum, arrived at above.

Plan.	Lamps fixed.	Annual consumption of electrical energy per lamp in Board of Trade units.	Total annual consumption of electrical energy in Board of Trade units.	Revenue at 6d. per unit (equal to 3s. per M. for gas).
				£
A + D combined	4,950	18	89,100	2,227
B + D "	8,700	18	156,600	3,915
C + D "	12,450	18	224,100	5,602

Cost of Working.

The staff required for working the station under the various plans would be:—

Officer	Duties.	A. and D. combined.	B. and D. combined.	C. and D. combined.
		Per ann.	Per ann.	Per ann.
Engineer ...	Complete management of the works...	£ 200	£ 200	£ 200
Junior Electrician ...	In charge of switchboard at heavy load	52	52	65
Do. ...	In charge at light load ...	52	52	65
Cleaner ...	Cleaning the plant and in charge at lightest load ...	52	52	52
Engine drivers	Driving engine at heavy load	91	91	182
Engine driver	Stoking and running engine at light load ...	91	91	91
Stoker ...	Heavy load	65	65	65
Lads ...	Odd jobs	26	52	52
Attendant ...	At sub-station	65	65	65
Do. ...	Do.	...	65	65
		£694	£785	£902

To which it would be wise to add for

Outside work—Jointer	£120	£120	£120

It being presumed with regard to the clerical work that it will be done by the present borough officials.

In addition to the staff, there will be the following expenses:—

Coal, 600 tons, 1,050 tons, 1,500 tons, at 9s.	£270	£472	£675
Oil, waste, &c.	90	150	200
Repairs	150	250	350
Water	nil	nil	nil
Insurance	20	30	40
	£530	£902	£1,265

Making a total cost of:—

Wages and salaries on station ...	£694	£785	£902
Outside	120	120	120
Materials, repairs, &c.	530	902	1,265
	£1,344	£1,807	£2,287

On the above basis the works' costs come out as follows:—

Plans.	Production in units.	Cost per unit in pence.
A + D combined ...	89,100	3·62
B + D " ...	156,600	2·79
C + D " ...	224,100	2·45

On reference to the table of costs which appears in *Lightning*, it will be seen the above estimates are not theoretical, but are based on experience of works' management, and that lower works' costs prevail in some electricity works producing greater outputs.

Name of company.	Output. Board of Trade units.	Works' costs per unit, pence.
Newcastle and District Electric Light Co.	290,469	2·90
Newcastle-on-Tyne Electric Light Co. ...	335,141	2·52
Birmingham	214,088	2·30
Bradford	401,540	1·96
Liverpool	796,281	1·86

and it may therefore be conceded that as the load on the Wakefield central station increases, the works' costs per unit would gradually decline.

On the other hand, it may be pointed out that in places where the economical system proposed for Wakefield is not in use, higher works' costs prevail.

Name of company.	1892 output. Board of Trade units.	Works' costs per unit, pence.
Southampton	35,537	5·64
Northampton	38,293	4·40
Eastbourne	107,842	4·67
Bournemouth	132,343	4·57

The London stations are omitted in both comparisons as affording no guide to working in Wakefield.

The plan proposed by me appears, therefore, to entail very cheap costs of working, and, if adopted by you, will, I feel certain, place you in the position of having one of the cheapest worked stations (of its size) in England.

The actual financial results to the Corporation would be as follows:—

Plans.	Capital outlay.	Margin for providing sinking fund.	Percentage of margin on capital outlay.
A and D combined ...	£12,650	£883	7 per cent.
B and D " ...	16,400	2,108	12 "
C and D " ...	20,200	3,315	16 "

As, however, the working of the four plants at the time of the top load would leave no margin of reserve, the more prudent plan would be, if the capital outlay under plans C and D be incurred, to keep on the 150 H.P. plant in reserve, and, at the time of the top load, to run the three remaining plants 20 per cent. above their normal capacity.

This would yield the following results:—

Plans.	Capital outlay.	Production units.	Cost of working.	Revenue B & D combined + 20 %	Margin.	Percentage on capital.
C & D combined	£20,200	187,920	£1,950	£4,698	£2,748	13½ %

Arc Lights.

I have made all my calculations on the basis of an incandescent plant. If, however, as suggested by me, arc lights are adopted for public lighting, the cost of working same would be 1¼d. per hour, if charged to the public lighting authority at 3d. per unit, which would fully cover the cost, in consequence of the prolonged number of hours of burning.

Every arc light would take up as much electrical energy as 15 incandescent lights.

I submit plan of the proposed central station, and, in conclusion, I beg to say that if there are any points upon which the Electric Lighting Committee would like to confer with me, I shall be happy to keep any appointment that they may fix.

(Signed) ROBERT HAMMOND.

AMERICAN ELECTRO-THERAPEUTIC ASSOCIATION.

THE following circular is issued by Miss Margaret A. Cleaves, the Secretary of the Association, and is well worthy of perusal:—

At a meeting of the Executive Council of the American Electro-Therapeutic Association, held at the office of the Secretary, March 2nd, 1893, the following resolution was adopted:

"*Resolved*, That the Secretary be instructed to prepare a circular to send to Fellows of the Association, to members of the medical profession, to electrical experts and to manufacturers of electrical appliances for medical work, containing titles of all the committees, the members serving on them, with their addresses and the matter prepared for discussion and investigation by each committee.

"And that manufacturers be asked to communicate with the members of the different committees, if they desire to have their instruments examined and tested, stating their claims and merits.

"And that physicians, electrical experts and manufacturers be asked to co-operate in making suggestions, and in relating their experience and preference for instruments, with reason and data.

"And to mail this circular to all members of the Association, manufacturers, medical journals, and to others who are known to use electricity extensively, asking for a speedy reply, either to the Secretary or to the members of the respective committee whom it concerns."

In accordance with the above resolution the following has been prepared:

Committee on Standard Coils.

Dr. W. J. Morton, 19, East 28th Street, New York; Dr. A. H. Goelet, 351, West 57th Street, New York; Dr. Wm. F. Hutchinson, Providence, R. I.; Dr. G. J. Engelman, 3,003, Locust Street, St. Louis, Mo.; Mr. A. E. Kennelly, Chief Electrician, Edison Laboratory, Orange, New Jersey.

Points to be Considered.

I. Portability.
II. Practical mechanism of machines as adapted to physicians' use.
III. Range and rate of vibration.
IV. Electromotive force and its range in relation to resistances to be overcome.
V. The resistance of the coil producing these electromotive forces.
VI. The battery power required for individual coils.
VII. Shape of the generated wave of electromotive force.

Committee on Standard Meters.

Dr. Margaret A. Cleaves, 68, Madison Avenue, New York; Dr. Emil Heuel, 352, Willis Avenue, New York; Mr. W. J. Jenks, electrical engineer, 44, Broad Street, New York.

Points to be Considered.

I. A good meter should have a clear, legible scale, fairly uniform over the range, and not crowded at different points.
II. It should be capable of being noted or observed at a distance.
III. The resistance should be low.
IV. There should be no tendency to overheat with the strongest current employed.
V. It would be advantageous to avoid a shunt, if one milliampère can be read throughout the scale.
VI. The instrument should be capable of indicating in all positions.
VII. Any instrument whose indications depend directly upon the local magnetic force is objectionable, for the reason that its indications are liable to be affected by iron in the vicinity.
VIII. The suspended system should require as little attention as possible, either for adjustment or shipment.
IX. It is an advantage for the instrument to indicate with either direction of the current.
X. Portability.
XI. Liability to fracture.

Committee on Standard Electro-static or Influence Machines.

Dr. W. J. Morton, 19, East 28th Street, New York; Dr. J. H. Kellogg, Battle Creek, Mich.; Dr. G. Betton Massey, 212, South 15th Street, Philadelphia; Dr. Margaret A. Cleaves, 68, Madison Avenue, New York.

Points to be Considered.

I. Electro-static machine best adapted to medical work, to be determined by its output. Its output to be determined as follows:—(*a*) At, respectively, 100 and at 150 revolutions per minute. (*b*) With two Leyden jars, each of whose outer metallic surfaces has the area of $4\frac{1}{4} \times 1\frac{1}{16}$ inches $= 5\frac{5}{16}$ square inches. (*c*) With discharging rods having ball terminals 1 inch in diameter and arranged respectively 6 inches and 10 inches apart. (*d*) Give the number of sparks per minute which will pass between the discharging rods.

II. Give the greatest maximum length of spark with machine arranged as in Section I., except as to distance apart of the discharging rods.

III. Give the maximum length of the brush discharge between the discharging rods with machine arranged as in Section I., except that no Leyden jars are used.

IV. Give the maximum length of spark that may be obtained by a brass ball electrode 2 inches in diameter, from a person's back, seated in the usual manner upon an insulated platform—the platform connected to one prime conductor of the machine, the other being connected to the ground. (*a*) With above Leyden jars. (*b*) Without Leyden jars.

V. Kind of electro-static machine best adapted to medical work, whether a Holtz, Wimshurst, Toepler, Voss, Carré. Lewandowski, Toepler-Holtz, Wimshurst-Holtz, or machine not here named, provided the type as constructed successfully fulfils requirements outlined in Section I.

VI. Does the machine preferred easily reverse its charge? Does it maintain its charge successfully?

VII. Facility and means of charging machine under all atmospheric conditions.

VIII. Can a good meter to measure the output of the machine be suggested?

IX. Mechanical construction of machine. (*a*) Ease of actuating machine by motive power. (*b*) Durability of the mechanism causing the revolution of its plates. (*c*) Durability of its construction. (*d*) Is a glass case necessary?

X. The best means for drying the air within an enclosing glass case.

XI. The best means for absorbing the ozone and nitrogen compounds formed within a glass case.

XII. Is it not advisable to decide in a general way that no machine, the diameter of whose revolving discs is less than 26 inches, and the number of whose discs is less than six should be recommended by this committee for medical work?

XIII. Suggestions as to a practical switch for the utilisation of Morton's static induced and the transformer currents.

Committee on Constant-Current Generators and Controllers.

Dr. W. J. Herdman, 48, East Huron Street, Ann Arbor, Mich., Current Controllers and Battery Tests. Dr. Robert Newman, 68, West 36th Street, New York, Primary Stationary Batteries. Dr. D. S. Campbell, Correspondence with Physicians. R. G. Brown, E.E., Brooklyn, N.Y., Stationary Batteries and Dynamos.

Points to be Considered.

I. Primary batteries.—Express what preference for a certain form of battery and give reasons therefor. Determine voltage, internal resistance current and durability. By what accessory appliances are currents from these batteries best controlled and applied?

II. Secondary batterics.—What are the defects and inconveniences? What the advantage over other forms? What the ampère hours, what the constancy, voltage, and action?

III.—As to dynamo currents.—What the nature of the current, what its voltages, how is it modified by the form of controller under consideration? What are its physiological effects and its therapeutical application?

IV. Report new forms of batteries and improvements, with claims as to superiority over those now in use.

V. Rheostats and controllers.—Test the various forms and devices used and recommended to modify and control currents; difference in effect produced by each, mechanically, chemically, physiologically, or therapeutically.

Committee on Standard Electrodes.

Dr. A. Lapthorn Smith, 248, Bishop Street, Montreal, Canada. Dr. Charles R. Dickson, 263, Victoria Street, Toronto, Ontario. Dr. Plym S. Hayes, 84, Washington Street, Chicago, Ill.

Points to be Considered.

I. Inactive electrodes.
1. What is the best material in general for the ground-work of the electrode and what in special cases?
2. How may it best be connected with its rheophore?
3. What is the best material to cover its conducting surface?
4. When necessary, how may it best be insulated?
5. In what way may it be kept warm and moist when not in use, should this be necessary?
6. What should be accepted as standard sizes and shapes, and how best designated?
7. What other points require to be considered?

II. Active electrodes.
1. What is the best material in general and in special for the ground-work of the electrode? (*a*) When used at the positive pole? (*b*) When used at the negative pole?
2. How may it be best connected with its rheophore?
3. What is the best material to cover its conducting-surface when necessary, in general and special?
4. How may it be insulated when necessary?
5. What is the best form of construction where flexibility is required for tortuous canals?
6. What shall be considered the standard shapes and sizes; what scale shall be adhered to in considering the latter; how may their surface area be estimated when they are of irregular shape?
7. When designated by numerals as to size and surface, how may such best be expressed when stamped or otherwise marked on them?
8. How may simplicity of construction be best obtained and cost of manufacture reduced without impairing efficiency.
9. How may facility of cleansing and rendering aseptic best be achieved.
10. What other points to be considered?

III. Active and inactive electrodes.

1. Are the terms "active" and "inactive" the best standard terms we can employ?

2. In the case of both active and inactive electrodes, should not the threads of all screws used in construction as a means of attachment, also all plugs and sockets, &c., be of a standard gauge, that electrodes might be used with attachments of all makes, &c., and to facilitate repair.

Since this circular was issued slight changes in some instances have been made in the points to be considered by the various committees. A committee on electric light as a therapeutic and diagnostic agent was created at the annual meeting of the association in Chicago, September 12th, 13th, and 14th, 1893.

Committee on Electric Light as a Therapeutic and Diagnostic Agent.

Dr. Plym S. Hayes, 84, Washington Street, Chicago; Dr. Margaret A. Cleaves, 68, Madison Avenue, New York; Dr. H. H. Hahn, 304, East Federal Street, Youngstown, Ohio.

Points to be Considered.—Therapeutics.

I. How can the heat of the incandescent and arc light best be utilised in the treatment of disease?

II. (*a*) What form of apparatus is best adapted for the use of the electric light in the treatment of disease? (*b*) Is there any difference in the therapeutic effects of the incandescent and arc lights? (*c*) Does the colouring of the light, by causing it to pass through coloured glass or similar substances, add to the efficacy of the light? (*d*) Is the light and heat derived from the electric light different or of greater therapeutic value than that derived from any other source? (*e*) What pathogenic germs have their growth arrested, or are killed, by continuous exposure to the influence of light? (*f*) Can a disease produced by the above mentioned germs be modified or arrested by the continuous exposure to light?

Diagnosis.

I. Illumination by means of a combination of the electric light reflectors and condensors so arranged as to furnish parallel or convergent rays of light. What form of apparatus is best adapted for general use? what for special?

II. What are the best forms of apparatus for illuminating the various cavities of the body, and at the same time enabling the physician to obtain a view of the whole or part of the cavity? Is the heat evolved, from the lamp employed, of sufficient intensity to require especial means for its absorption?

III. To what extent is the introduction of an electric light into the various cavities of the body, in order to determine the condition of those cavities or the translucency of the surrounding tissues, of advantage?

Your prompt and full reply is earnestly solicited to any or all of the points above suggested.

Margaret A. Cleaves, M.D., *Secretary.*

December 4th, 1893.

ELECTRIC LIGHTING AT NEWPORT.

The Question of Tenders.

Mr. Hammond and Messrs. Fowler & Co.

At the monthly meeting of the Newport County Council on Tuesday, the question of the acceptance of a tender for the work in connection with the electric lighting of the town engaged attention. The report of the Parliamentary and Improvement (Electric Lighting) Sub-Committee contained the following paragraph:—"The question of which tender should be recommended for acceptance having been discussed, the fact being taken into consideration that Messrs. Crompton & Co., whose tender is the lowest for the whole installation, have not had extensive experience of high tension alternating current work, and also that in only one section (B) is their tender selected as one that could be recommended. Resolved: "That the tender of Messrs. John Fowler & Co., being the next lowest for the whole work, at the sum of £23,384, be recommended for acceptance." The amount of Messrs. Crompton & Co.'s tender was £20,780. Mr. Hammond is the consulting engineer.

Alderman Davis, the Chairman of the Parliamentary and Improvement Committee, moved the adoption of the report. He had from the first, as a director of the gas company, refrained from interfering in the matter of electric lighting as far as possible, and he asked Alderman Moses to answer any questions.

Alderman Moses seconded the adoption of the report, and thought it would be well to say a few words on the subject. He might say, in considering the scheme, that a good deal of dirt had been attempted to be thrown upon the consulting engineer, and upon the contractors whom they, as a committee, recommended to the Council that day as contractors for the work. Mr. Hammond, the consulting engineer, was present there at his (the speaker's) request, and would give the members any explanation on the report, and certainly respecting himself and his connection with Messrs. Fowler & Co. He thought it was due to Mr. Hammond, seeing that every member of the Council had had a circular sent to him—he had had one himself, and he presumed every other member had had one also—he thought it was due to him to explain his position with respect to Messrs. Fowler & Co., and it was also due to the committee. He might say that Mr. Hammond was well known, and he was surprised at what people said, because they knew there were no grounds for it. There was a great amount of jealousy amongst the whole of the people who tendered for the work, and also a vast amount of jealousy amongst the competitors for the post which Mr. Hammond held. All could not be successful, and only one could be appointed. The unsuccessful competitors considered him fair game to go at. Mr. Hammond was capable of taking care of himself, and giving an explanation. The report of the sub-committee recommended that Messrs. Fowler & Co. should do the work. The committee had been considering the matter for a long time, and had presented various reports from time to time. These reports had been received, and always considered satisfactory. Now they came with the final report before the works were constructed, and recommended a contractor to do the work. They had been around to different central stations in the country, and had been strongly impressed with the superiority of the work which had been constructed by Messrs. Fowler & Co. They, therefore, recommended that Messrs. Fowler and Co. be instructed to do the work. The tender of Messrs. Fowler amounted to £22,524, and that of Messrs. Crompton & Co. was £20,780. They believed, as a committee, that the work should be entrusted to one firm. He thought every member of the Council had had Mr. Hammond's report, and he had no doubt that they had studied it. The one firm was recommended to do all the work with the exception of the cables, and it was proposed that this work should be done by Messrs. Siemens & Co. Two firms would be responsible for carrying out the whole work. They wanted their undertaking to be a success, and not a failure; and they were strongly impressed with the work of Messrs. Fowler & Co., and which they thought was calculated to be a success. Alderman Moses went on to say that Messrs. Fowler's contract, including the cables, would be £22,524, and Messrs. Crompton's £20,780. The sum put down by Messrs. Fowler for their cables was £3,756, and deducting this from the £23,384, there would be left £19,628. Then they had the figures given that they would have to pay Messrs. Siemens, £2,986, making a total of £22,524 for the whole of the work, and that of Messrs. Crompton £20,780. But the sub-committee did not approve of the work that Messrs. Crompton proposed.

Replying to Alderman Vaughan,

The Town Clerk stated that Messrs. Crompton's tender for cables amounted to £3,318.

Alderman Moses: We (the sub-committee) decided that the extra money we propose to pay Messrs. Fowler will be well spent.

Alderman Griffiths enquired what was the amount of extra money to be paid to Messrs. Fowler.

Alderman Moses replied that the one tender was £22,524, and the other £20,780. The total figures were—for Messrs. Fowler's work and Siemens's cable £22,524, and Messrs. Crompton's, allowing for cables, £20,295. He thought it was due to Mr. Hammond that he should have an opportunity of speaking.

The Mayor said he had several letters sent to him on the subject. One of these was from Messrs. Fowler, explaining their position; another from the Newport Trades Council, urging that consideration should be given to local firms in letting out the work; and the third from Messrs. Crompton, calling in question Mr. Hammond's action.

Councillor Wilkinson enquired whether the committee, before deciding to accept the tender of Messrs. Fowler, due consideration was given to the Newport firm, especially considering the great depression which had existed for a long time among the engineers, plumbers and boiler makers of the town. He also asked why the committee accepted the tender of Messrs. Fowler in preference to that of Messrs. Crompton, seeing that the former exceeded the latter by £2,200.

Councillor Brown replied that the report was an answer to that.

Councillor Wilkinson moved that the matter be referred back to the committee for consideration.

Councillor Brown maintained that the council should deal with this report in the same way as any other report. To bring the whole matter before the council, he moved that paragraph No. 25 of the report, which recommended the acceptance of Messrs. Fowler's tender, be referred back to the Parliamentary and Electric Lighting Committee. He did not think that this question should be settled without first of all giving Crompton an opportunity of seeing the committee. It was not only the question of expenditure which the council should consider, but the matter of the efficiency of the work as well. The one could not well be separated from the other. It was strange that the committee should recommend the acceptance of the tender £2,000 above another tender. The question was whether the firm whose tender was recommended for acceptance had had a more lengthened experience in electrical work, and whether they occupied a more superior position in this particular branch of work than the other. He (the speaker) had made enquiries, and he had been informed that Messrs. Crompton had a much longer experience in the particular work than Messrs. Fowler. If this were so, it was strange that Messrs. Crompton should be passed over. He (Councillor Brown) had every confidence in the sub-committee, who had the selection of the engineer; and he did not think any member of the committee would be a party to a job, such as appointing an engineer who had collusion with a firm tendering for the work. Then there was a point which weighed considerably with him, and this was the local view. In going through the report he found that Messrs. Crompton gave a tender to supply engines which could be made by a local firm—the Uskside works. If the work could be placed in the hands of a competent firm, and this firm encouraged local industries, the council should go as far as possible in meeting that. There were numbers of skilled mechanics walking about the town. Then the Chairman of the Committee stated that they were struck by the superiority of works at central stations as laid down by Messrs. Fowler & Co. But did the committee visit the central stations where works were laid down by Messrs. Crompton?

Councillor Wilkinson seconded the motion. He said he did not

think that Messrs. Crompton had had fair play in this matter. Messrs. Crompton was a firm of the very highest standing, and its guarantee was equal to that of the Bank of England. Taking this in conjunction with the interest of the ratepayers, why should Messrs. Fowler have the preference, when so much money was at stake? The committee should not be led entirely by Mr. Hammond. He looked on the business with a certain amount of suspicion, on account of the apparent connection between Mr. Hammond and Messrs. Fowler in the past.

Councillor JONES stated that probably the sub-committee had given more attention and trouble in dealing with this question of electric lighting than any sub-committee had ever given to any subject which occupied the attention of the council. An electrical engineer, who was perfectly competent, had been appointed to advise the council in the matter, and the sub-committee was perfectly prepared to stand by the report presented to the council. In recommending the acceptance of Messrs. Fowler's tender, the committee thought it was the right one, having regard to the importance of obtaining a really efficient and satisfactory station when built. It was proposed to-day that the matter should be referred back, in order that one gentleman should be allowed to interview the sub-committee. He had not had the honour of meeting the gentleman who had been in the town advocating the claims of Messrs. Crompton. There seemed to be some pretty great charges brought against the sub-committee; but he could not now see the use of referring it back to them. From a cursory examination of the drawings, he did not think there was anything like the value in Messrs. Crompton's installation as in that offered by Messrs. Fowler. If the recommendation of the sub-committee be adopted, the council would not only be in a position to supply electricity by the coming autumn, but they would also have in Newport one of the most complete and satisfactory installations found in the kingdom.

Councillor LLEWELLIN inquired if the work were let in two contracts—one to Messrs. Fowler and the other to Siemens—would Mr. Hammond, on behalf of the corporation, be responsible to the council for the efficiency of both contracts.

Alderman MOSES replied in the affirmative.

Councillor LLEWELLIN asked, if that were so, what object was there in passing over Messrs. Crompton's tender.

Alderman MOSES replied that there was a different class of machinery in the tenders. The machinery which the sub-committee had seen, and which was embraced in tender now recommended, was second to none in the kingdom; and the installation, if laid down in Newport as the sub-committee recommended, would be second to none in the kingdom. The committee had seen some machinery like that made by Messrs. Crompton, but they did not like it.

Councillor MORDEY thought it would be desirable to refer the matter back to the whole council in committee. The sub-committee had been two years considering the question, and bringing up their report, asked the Parliamentary Committee to accept it. The latter considered for two hours what the sub-committee had been giving attention to for two years; and now the whole council were asked to accept it in a few minutes. Messrs. Crompton had written, stating that they had more experience than Messrs. Fowler; and, if this were so, why should not the matter be carefully gone into, and give Messrs. Fowler a fair opportunity of rebutting this. The council had gone broadcast to the country. They had 60 tenders; and were they in a few minutes to wipe out the people who had spent hundreds of pounds in plans and specifications? He said no; especially the two or three now mentioned. It was not right to go to the public, advertise for sections, and ask for tenders, thereby putting firms to hundreds of pounds' expense, when there was no intention to take any account of them. If the engineer were going to advise the acceptance of one tender, why did he not do so at the outset?

Councillor GREENLAND enquired whether it would be convenient for Mr. Hammond to make a statement then. It was not a question of £2,000 extra, but one of the efficiency of the plant. He had a little idea about electric works, and thought that everything depended upon the perfection of the machinery. The committee reported that the machine proposed to be supplied was the most perfect, and he supported their report.

Alderman VAUGHAN said he could not see that in referring the matter back to the committee it would not be impugning them in any way. Circumstances which had come to their mind since the reports were issued were such as to justify to a considerable extent the matter being referred back. If Messrs. Crompton was prepared to give a guarantee that their plant should be equal, if not more efficient, than Messrs. Fowler's, that ought to be a sufficient guarantee—sufficient, at least, to refer the matter back to the committee. It had been stated that the committee had seen Messrs. Fowler's machinery in operation; but had they seen any from the works of Messrs. Crompton? Their consulting engineer had been intimately associated with Messrs. Fowler & Co. This association had not only been one of friendship, but he had been actually in partnership with them. Although he was not now associated with them, such an intimate acquaintance as that could not be broken off in a moment. Many questions had already arisen from the report. He considered that the committee were no more enlightened on the matter than he was, and that they had been led by their engineer.

Councillor PARNALL: Not in the least, sir.

Alderman VAUGHAN: What can you do otherwise? Proceeding, he alluded to several items in which the tender of Messrs. Crompton and Co. was more favourable to the corporation than that of Messrs. Fowler & Co. He quite agreed that there should not be divided responsibility. He thought if Messrs. Crompton & Co. were prepared to give a guarantee as to the efficiency of the machinery—and, furthermore, that they would construct the machinery to the entire satisfaction of their consulting engineer—the report should be referred back. He hoped every member of the Council would vote for that course.

Councillor PARNALL said he would take a full share of responsibility as a member of the sub-committee whose report came before them. The specification had been before them for a month, had been advertised in all the papers, and tenders had been received upon those specifications. The tenders had been opened, and now some of the unsuccessful men came in, wanted to explain, amend their tenders, and endeavour to get the contract.

Councillor LLOYD: May I ask who wishes to amend his tender?

Councillor PARNALL: Messrs Crompton. (Cries of "No.") He further stated that Mr. Hammond's report was the most impartial one that could possibly be made. His friend, Mr. Mordey, had said that the sub-committee had spent two years on the question, and they knew very little about it. As far as he was concerned, he was not entirely in ignorance, and had been working electrical machinery for years. With regard to the commercial position of Messrs. Crompton, they were a highly respected and well-known firm, but they represented what was commonly known as the low-tension system. They had decided that the low tension system was no use for Newport, and had adopted the high tension. One of the principal points in favour of Messrs. Fowler's machinery was the switchboard. This little item was important, and there was as margin in the tenders as between £1,705 and the £465 of Messrs. Crompton. Well, now, they had pronounced against the one switchboard. It was a very complicated part of the installation, because, if he might so explain it to them, the whole of the electricity that was generated was gathered up in the omnibus part of this switchboard, and distributed over the district where it was to be consumed. Then there was the question of the dynamo, and Messrs Fowler would suit them best.

Councillor MORDEY: Have not Messrs. Crompton & Co. tendered for the high tension system?

Councillor PARNALL: No.

Alderman MOSES: Yes—for the high pressure system.

Councillor MORDEY then enquired why it had been stated that they only dealt with the low pressure system.

Councillor PARNALL replied that it was because they applied the low tension machinery to the high tension. He added that he should have been glad if some Newport firm could have secured a portion of the work.

Councillor THOMAS said he believed that their Parliamentary powers would expire in a short time, and he wished to ask the Town Clerk if there would be any difficulty in getting the powers extended or revived. He ventured to say that the longest possible period for which they could put off the construction of these works the better. Mr. Alderman Moses said it was the study of a lifetime. Electricity was being continually improved, and first-class machinery of the present day would soon become a matter of ancient history. Mr. Councillor Jones said that if the tender which the sub-committee recommended was accepted, it would be one of the most complete and efficient works in the country. That he believed, and he believed that in the course of a few years they would be surpassed by other towns. If a vote was taken that day, he should support the report of the committee.

Alderman VAUGHAN thought that the engineer should not be called upon to explain there.

Councillor RICHARDS did not think the matter was so urgent that it could not stand over for a month.

Councillor PARFITT wished for information on the matter. Since he had been a member the lowest tender had always been accepted, and why was that rule broken now?

Councillor WILKINSON suggested that a vote should be taken.

Councillor BROWN said the object of his motion was that Mr. Hammond and Mr. Crompton should attend before the committee.

Councillor JONES: If charges are made in public, Mr. Hammond ought to have an opportunity of answering them in public.

Alderman VAUGHAN: I say distinctly and emphatically that I have not heard a single charge brought against Mr. Hammond to-day. He added that he strongly disapproved of introducing matters of a controversial character. It would be far more dignified for the Parliamentary Committee to hear Mr. Hammond and Mr. Crompton.

In answer to Councillor MORDEY, the TOWN CLERK stated that the tender of a local firm which had been sent in was not in the proper form.

On a division being taken as to whether Mr. Hammond should make an explanation, it was decided by 15 votes to 13 to hear him.

Mr. HAMMOND then addressed the meeting. He said he wanted the council to feel that they were all pulling the same way. Certain things, however, had been said about him, and as an Englishman he felt the imputation cast upon him. He could look for help to gentlemen to assist him in meeting the slanders cast upon him by his opponents. For 14 or 15 years he had been engaged as an electrical engineer and contractor. Last year he was called upon as electrical engineer to advise the laying down of works at Leeds. He laid down, acting as engineer and contractor, as many men in his profession did now; one day acting as consulting engineer, and the next day, on the same job, as contractor. A few days after he made up his mind that he should not be in an anomalous position any longer. As a contractor he had carried out some of the finest works in the kingdom; but he decided not to remain a contractor. But he could not cut this off at once. At Coventry he said he could not take the contract, having put in a joint tender with Messrs. Fowler; and he said that the only thing was to make him consulting engineer, he stating that he would make Messrs. Fowler do the work, because he knew every inch of their plant. He (the speaker) had authority for stating that, on its merits, Messrs. Fowler's tender was the best at Coventry. It had been said that he started as an electrical engineer, going on to contracts. This was not true. It was also stated that he sometimes got 5 per cent. for certain works. Well, most gentlemen got something out of the business they transacted. He did not want to take advantage of the opportunity given to him to plead the cause of any particular tender. He felt it his duty to say that, all things being

equal, at about the same prices, the council would gain by putting the work into one hand. If some thousands of pounds could be saved by cutting the contract up into sections, he could urge this to be done; but he felt bound to say that if there was any way of getting the work into one hand—the prices being about equal—it would be an advantage to do so. If the council desired the cheapest tender, they could save £4,000. The speaker, alluding to Messrs. Crompton, stated that they occupied an eminent position in the electrical world. Mr. R. E. Crompton was a past president of the Institute of Electrical Engineers; and the firm had carried out some most important works. Therefore any proposition from that firm would command great attention from him. But Mr. Crompton's fame and experience had been built up in making installations on the low tension system. Mr. Crompton had been the bitter opponent of the system adopted in Newport; but he would be compelled to accept the high tension, for he was now stepping out of the old groove. In laying down installations, the first thing to seek was that the light turned on should never practically cease; and in the first installation, choice should be made of one which had experience behind it. Messrs. Fowler had an experienced man at the head of their high tension work; and the firm made the high tension system a speciality. His idea was to have in Newport a magnificent installation, which a neighbouring town would envy.

Alderman MOSES said there was only one tender from a Newport firm, and he thought he was correct in stating that if Messrs. Fowler got the contract Messrs. Spittle (Newport) would have the work of making the culverts.

The proposal of Mr. Brown was then referred back to the Parliamentary Committee, this being carried by 21 votes to 11, so that the representative of Messrs. Crompton may have an interview with them.

CORRESPONDENCE.

Professors and Consulting Engineers.

Prof. Jamieson's letter on the above subject last week gives one the impression that *he* thinks that a man—*professor* rather—who has "gone through the mill" must of necessity have become a *practical* engineer in the process.

The writer's experience—and it is doubtless the experience of many others—of *some* professors as practical consulting engineers is, that they have proved themselves anything but practical.

Perhaps the Professor has forgotten that there is more than one *shoot* in a mill, and products differing widely in quality, such as flour and bran for instance, issue therefrom.

A.I.E.E.

Electric Lighting at Leicester.

I notice in a long article in the *Leicester Post* on electric lighting, it is stated that the first dwelling house lighted throughout by electricity was that of J. D. Harris, and was lighted by Woodhouse & Rawson; also that the second factory lighted was also the work of that firm. I was in that firm, but did not know that the above installation was actually the first erected, and I should like to know as a matter of interest whether this is the case. There is a good deal of useful and interesting information in the article.

Ajax.

BUSINESS NOTICES, &c.

The Universal Electrical Directory (J. A. Berly's).—The above directory is now in the press, and all insertions, corrections, and advertisements for the 1894 issue, should be forwarded at once to H. Alabaster, Gatehouse & Co., 22, Paternoster Row, London.

The State of Trade during 1893, and Prospects for the New Year (*continued from page* 13).

The Brush Electrical Engineering Company, Limited, have, during the year, had their works employed upon all classes of electric lighting contracts, particularly those for plant for central electric lighting stations. The large and important contract for lighting the City of London has made great strides towards completion during the past year, there being now delivered at Bankside Station (in addition to the plant originally put down there), six sets of Raworth-Mordey combined alternating plant with an aggregate output of 2,500 kilowatts, and the equipment of the various transformer stations is now fast approaching completion. The original contract for lighting the town of Huddersfield has now been completed and orders for considerable extensions have already been received. Additional plant has been supplied for the central stations at Sheffield, Bournemouth, Hastings, and Woking. Among the other central station contracts secured during the past year may be mentioned those of Leicester, Lancaster, Dover, Canterbury, Fleetwood, Coatbridge, and those for the supply of alternators and arc lighting plant to the Great Northern Railway Company, Holloway, and to Hastings and Blackpool for lighting the promenades on the sea front; alternators, exciters, and transformers to the Bolton Corporation, the complete equipment of the transformer sub-stations for Bristol; and the supply of alternate current plant for the station at Rugby School. With some of these and with the contracts previously secured for corporation stations at Worcester and Hanley, considerable progress has been made; while the supply of plant for stations at Prescot, Windermere, and Killarney, and at several other places mentioned above, has been completed. The Brush Company's contracts for exhibition lighting have included this year the supply of the whole of the electrical plant at the Horticultural Exhibition, Earl's Court; and amongst the most important orders in hand for isolated installations may be mentioned the lighting of Arundel Castle, the seat of his Grace the Duke of Norfolk; the residence of Sir Arthur Hayter, Southill Park, Bracknell; Battenhall Mount, Worcester, belonging to the Hon. Percy Allsopp; High Trees Mansion, Redhill, belonging to M. Marcus, Esq.; and the supply of arc plant on a large scale for the important installation at the Midland Railway Company's station at Leicester. The installation work on ship-board completed by the Brush Company has comprised electrical plant for two vessels belonging to the Pacific Steam Navigation Company; two cruisers for the Argentine Government; extensions to the plant of the S.Y. *St. George*, &c., &c. With regard to the internal organisation of the company, the special facilities possessed by the company in their woodworking and foundry departments at Loughborough, have enabled them to contract for the exclusive manufacture of the lifts and hydraulic machinery to the orders of the Otis Elevator Company, an off-shoot of the American Otis Elevator Company, and it is anticipated that this will be an important branch of the Brush Company's manufactures in the future. Having perfected a system of alternate current distribution, the company have been giving attention to the further development of their continuous current plant. With this in view they have acquired the sole rights for manufacture in the United Kingdom of the Brush-Desroziers dynamo—a machine which has become a deserved favourite in the central stations on the continent. They have also begun to manufacture several classes of two-pole dynamos of high efficiency and moderate price, which are finding many buyers. To all these types as well as to their well-known Mordey-Victoria alternator the company attach direct engines of their own special make. This does not, of course, preclude the supply of belt or rope driven engines where these are desirable, but is undertaken in order to meet the growing demand in central stations for direct driving. Important improvements have been made in the company's transformers, alternate current arc lamps and lamp-posts, accompanied by substantial reductions in price; and at the same time particular prominence is being given to the supply of plain fittings, switches, and lampholders, which will shortly be on the market at most favourable figures. The expiration of the Edison patent in November removed an obstacle which had for years barred the field of glow lamp manufacture from general exploitation in this country. The Brush Company made extensive preparations to resume their former position in this branch of the electrical industry, relying on their name as a guarantee for first rate material and high-class workmanship, and feeling confident that the re-appearance of their lamp would be welcomed on the market where the Edison lamp had so long been in sole possession. They have been gratified by the ready and wide-spread sale with which the Brush glow lamps have met, and are looking forward to a steady and still larger demand than even the initial rush has brought upon Mr. Alwyn, of 53, Queen Victoria Street, E.C., in whose hands the whole of the sales in Britain has been placed. In its other departments also, the company continues to be occupied fully with large and remunerative orders to an extent that taxes their resources to the utmost, notwithstanding the enlargement of their works and the increase of their staff.

Messrs. Doulton & Company, of the well-known Lambeth potteries, in addition to their usual trade in telegraph and telephone insulators and pottery parts for electrical apparatus, have been supplying during the past year their patent stoneware conduit for underground cables to several London and provincial supply companies. It is claimed that this conduit, while it is easily laid, strong and imperishable, is the cheapest system that provides a separate "way" for each cable. It is specified for some important works that will shortly be in progress. Messrs. Doulton make a speciality of vitrified stoneware insulators for bare copper mains, and have designed special plant for their manufacture in large quantities. They have recently supplied these insulators for the lighting of Oldham, Aberdeen, &c.

Messrs. Johnson & Phillips's electric lighting branches have been well maintained, several of them having been exceptionally busy. Contracts for cables, arc lamps, and accumulators, have necessitated an unusual amount of overtime to meet the pressure in these departments. Fresh additions to the buildings and machinery are now in progress. It will be remembered that in our last year's summary we referred to the Brooks's system of mains, which Messrs. Johnson & Phillips were then on the point of completing for the Chatham and Rochester public street lighting. They now report the completion of this contract, and point out the successful working which has attended the installation during the past 12 months. The mains comprise about 12 miles of conductor, and are fitted with junction boxes, house service, and terminal boxes. The cables are placed in heavy wrought-iron tubes, which are then filled with a highly insulating oil, and hermetically sealed, thus securing an insulation, which, besides being permanent and reliable, is subject to

practically no deterioration. The Brockie-Pell lamp still holds a strong position. New workshops have been fitted up during the year to cope with the ever increasing business in them. Hull, Blackpool, Bristol, Portsmouth, Londonderry, Oxford, and Burnley, are amongst the towns where they have been adopted for street lighting. Other places where they are to be found are:—The Imperial Institute, Blackpool Winter Gardens, Woolwich Arsenal, Bute Docks, and the stations of the London and North Western and Great Northern Railways. They have also been shipped in large quantities to Russia, South Africa, New Zealand, and other places abroad. The Gardens and Forestry Exhibition, at Earl's Court, was illuminated by means of these lamps. Cables and wires for electric lighting and other purposes have been demanded at such a rate that has necessitated working day and night at them for a considerable portion of the year. New and commodious shops are now being erected to relieve the strain. The Perry meter, which has been taken up during the year, promises to become an important factor in the business of the firm. Large numbers have been made, and the shops are equipped with all necessary plant for their manufacture on a large scale. To make a dynamo so self-regulating as to give not more than 2 volts variation up or down, between 55 and 360 ampères, has been one of the tasks undertaken by Messrs. Johnson & Phillips during the past year, and they claim to have solved the problem in a very satisfactory manner, three large multipolar machines of this description having been constructed. Other specialities have been a novel motor alternator set, for use at the University College, London, arranged to work either off the public mains or by means of belt power; and a large multipolar steam dynamo for Her Majesty's Military Electrical School, Chatham. The former is so designed as to demonstrate all phases of alternate current working. The firm's latest and most successful transformer is commanding a very large sale. The large ones recently made for Bristol are arranged for the three-wire system.

Messrs. Laurence, Scott & Co., Limited, report that they have been exceedingly busy during nearly the whole of the last 12 months, and their works have been taxed to their utmost capacity. The company have completely fitted up the Norwich Electricity Company's supply station, and have already had a repeat order for extra plant. The station has several new features. Among others, Mr. Scott's patent meter system is adopted, by which it is arranged that supply in the daytime, and after 8 at night, is charged at half-price. The new system of underground mains, which is in use at the station, is also the invention of Mr. W. H. Scott. It has proved remarkably cheap and convenient, and is giving complete satisfaction. Messrs. Laurence, Scott & Co. have further been engaged in some large electric transmission of power work, and their ordinary business of the manufacture of dynamos, motors, &c., has also been fairly good.

Mr. A. P. Lundberg reports an exceptionally busy year, supplying his various specialities in electric light fittings. He has been specially busy with the patent "Unique" switch, introduced in January, 1892. The total sale of this speciality, in its various sizes, now reaches 45,000. He has been favoured with a very fair export trade to the Continent, United States, and the Colonies. From the large number of orders in hand, Mr. Lundberg remarks that he has every reason to expect equal success in 1894.

Messrs. Paterson & Cooper have been fairly well employed. The following vessels have been fitted with complete installations:—ss. *Matin*, for Messrs. Mudie & Sons, Dundee; *Princess Beatrice*, for Messrs. Langlands & Co., Liverpool; *Laurentian*, for the Allan Line; *Empress*, for P. Carson, Esq., Hull; *Zaire*, for F. T. Laws, Esq., Liverpool; *Noir-el-Bahr*, for Messrs. Gourlay Brothers, Dundee. Direct driving sets for the ss. *Premier*, of the Canadian Pacific Company, and for other vessels have been supplied. Complete search light apparatus, with direct driving set, has been supplied for a revenue steamer. The principal installations carried out have been the private residence of H. W. Buddicom, Esq., Penbedw, North Wales; comprising a direct driving set, 101 L-31 accumulators, fitting of mansion with lights and bells, and several motors for sawing, pumping, churning, &c. The private residence of M. G. Thorburn, Esq., Glenormiston, Peebles, comprising turbine and dynamo, cells and fitting lights in mansion; Jury's Hotel, Dublin, 300 16-C.P. lights with direct driving set running at 175 revs. per minute. The private residence of W. Aretty, Esq., Ipswich; Messrs. Flower's corn mill, at Ramsey; the Ocean Iron Works, Manchester, the Town Hall and Royal Hotel, Derby; the Great Northern Hotel, King's Cross; the Queen's Hall, Portland Place, &c., &c. In small work, Admiralty contracts of considerable size have been executed during the past year, Messrs. Paterson & Cooper introduced their new patent 5-ampère lamp, which has met with a very favourable reception; they have also brought out improved electrical measuring instruments which have met with approbation, and have taken up the agency for Messrs. Richard Frères' electrical measuring and recording instruments. Of works at present in hand, the most important are:—Messrs. Buchanan & Sons' works, Liverpool, 22 arc lights and dynamo; the private residence of R. K. Micklethwaite, Esq., Ardsley House, Barnsley; and the Municipal Buildings, Ealing.

Messrs. Rowland Barnett & Co., of Walker Gate.—The following are some of the contracts carried out during the year. Complete electric lighting plant for the Tyne Steam Shipping Company's steamer *Juno*, consisting of combined steam engine and dynamo for supplying about 80 lights of 16 and 32 candle-power, two 500 candle-power lamps for working the cargo, and one 2,000 candle-power arc lamp of special design, complete. The plant for North Bitchburn Colliery, including steam engine and dynamo and about 90 lights of 16, 25, and 32 candle-power, one 100 candle-power, and two 200 candle-power, the plant being capable of lighting 200 lamps of 16 candle-power each. The current is carried about 700 yards underground. The firm have also fitted up about 50 business premises, &c., using about 500 incandescent lamps of from 8 to 500 candle-power, and 20 arc lamps of 2,000 candle-power each. Owing to the enormous increase in business during the past year, Messrs. Barnett and Co. have been compelled to take larger premises for town show rooms and offices, and they intend to considerably increase the size of their works at Walker Gate for the manufacture of their new north-eastern dynamo, which was awarded the only gold medal at the recent Trades and Industrial Exhibition in Newcastle.

Messrs. Russell & Co. report that they have carried out a considerable amount of wiring and general contracting work during the year, among which may be mentioned a large private house of 144 lights in Holland Park, a flat in Albert Gate of 42 lights, two shops for the British Tea Table Company, and an installation of arc lamps and dynamo for the lighting of a paper staining works. They have also carried out the wiring of several country houses, among which may be mentioned the supply of accumulators and extensive alterations for Sir Charles Murray, K.C.B., at Old Windsor. A large house at Richmond, belonging to the Crown, has been successfully fitted with lightning conductors. Messrs. Russell & Co. took over the contracting business of Mr. Medhurst, of Cambridge, as late as August in this year, and have already experienced a considerable increase of work, especially for Clare College and the Corporation, besides very many small shops and houses. A special feature is the temporary illumination of a large field for skating purposes. They have at present several important contracts on hand.

Messrs. Swinburne & Company, Limited, report that they were very busy during last year. They were compelled to work overtime almost continuously in the last six months. Among the more important contracts completed, is that for a set of motor alternators for the Woolwich Electric Supply Company, to be worked in conjunction with the Pritchett secondary battery. Turning to other things, their small and large power alternators have met with great success, and the demand for these and for their ordinary direct current machines show signs of rapid increase; the same remarks apply to their new closed circuit transformer, which has proved a great success wherever it has been tried. In the instrument department they have devoted themselves chiefly to perfecting the Swinburne electrostatic voltmeter, which is now gradually taking its place as the recognised alternate current voltmeter on central station switchboards. The installation department has also made considerable progress during the year. A large number of orders are on hand in all departments, and the outlook for the coming year is very promising.

The Telegraph Manufacturing Company, Limited, report that they have been extremely busy in all departments during 1893. Their vulcanised cables have had a large sale, and they have supplied a large quantity of both high and low tension mains to various contractors for town work. In their instrument factory they have been favoured with large orders from the Postmaster-General, railway companies, &c., and they have found their sales increase in every department.

Messrs. Woodhouse & Rawson United, Limited, report a fairly satisfactory year, especially considering the financial difficulties they went through at the beginning of the year. The business which is being carried on as usual by Mr. F. D. Leslie, Receiver for the debenture holders, fell off to some small extent at the beginning of the year, since when there has been a gratifying increase each month. A few of the branches and agencies have been closed, but in such important centres as Birmingham, Glasgow, and Bradford, they have been kept open as well as at most of the foreign branches, with highly satisfactory results. In South Africa they have had some very large contracts in the way of transmission of power and lighting jobs, and are now engaged in putting down a central station and erecting a large telephone installation. A further large station plant has in addition just been ordered by cablegram. The whole of the engines, boilers, and dynamos for this heavy work, is being carried out at Kidsgrove Works, which are at present in full swing. The electrical work formerly carried on at the works at Hammersmith, has been removed to Manchester, in consequence of which it has been found necessary to put down further plant, including automatic machinery of high-class manufacture. During the year they have been very fully employed in manufacturing a great variety of electrical machinery and instruments, including a large amount of railway signalling apparatus. Their Bradford house has also been busy in carrying out the following installations:—Borough Surveyor's office, Huddersfield; C. & J. Hirst, mill, Huddersfield; G. A. Carr & Co., mill, Grimsby; John Foster, Esq., private residence, Egton; J. H. Haggas, Esq., private residence, Oakworth; Joseph Nicholson, Esq., private residence, Leeds; C. F. Tetley, Esq., private residence, Leeds; Yorkshire House-to-House Electricity Works, Leeds; Harrogate Hydropathic Establishment, Harrogate; Col. E. Cotton Jodrell, (extension), Nantwich; Low Moor Iron Company, Limited, works, Low Moor; Manfield & Son, shop, Hull; Sir Titus Salt, Bt., Sons and Co., Limited, mill, Saltaire; Sir Titus Salt, Bt., Sons & Co., Limited (three installations), Saltaire; Sir Titus Salt, Bt., Sons and Co., Limited, warehouse, Bradford; Saltburn Estate, salt works, Saltburn; T. Taylor & Sons, mill, Barnsley; Bradford Corporation Electricity Works, Bradford; A. Bronner, Esq., M.D., chambers, Bradford; Heymann & Alexander, warehouse, Bradford; J. Barraclough & Co., offices, Bradford; North Brierly Union, offices, Bradford; H. Farrer, offices, Bradford; New York Insurance Company, offices, Bradford; S. & S. Musgrave, offices, Bradford; N. W. Noakes, shop, Bradford; J. S. Douglas and Co., shop, Bradford; Bradford Provident Ind. Company, shop, Bradford; Messrs. E. Holmes, shop, Bradford; Taylor & Parsons, shop, Bradford; George Holt, shop, Bradford; F. W. Leigh, shop, Bradford. Their business at Birmingham has been more confined to supplying electrical contractors, and the manager reports a steady increase of sales in all departments. The new process for cleaning

brazed joints in cycle frames, and other branches of Birmingham and Midland trade, is being pushed forward for the coming season, and is likely to prove of great value to the local manufacturers. The Scotch branch, although the last opened, has done exceedingly well. They have carried out the mill and mansion lighting for Messrs. Pollock & Co., of Balfron, Stirlingshire, which is a most complete installation. The power is derived from the river Endrich by means of a Brest wheel, which drives the mill machinery. From this is driven a "W. & R." shunt-wound dynamo with extra bearing, so as not to have the pulley over-hung, having an output of 130 volts and 52 ampères at 1,000 revolutions. This is used to charge a battery of 53 R-5 Epstein cells. The whole installation is arranged to work automatically with the least possible personal attention. In conjunction with the cells is a Barber-Starkey cut-in and cut-out, which answers exceedingly well. For shop lighting, the small "Midget" lamps have been taking exceedingly well, and are being used with much success in Greenock and other places. Some house-wiring in Edinburgh, to run from the Edinburgh Corporation Supply, when ready, has also been done. In London, installations have been carried out for the *Yachtsman*, Carrell, Strachan & Lardelli, Mellor and Mellor, Royal Military Tournament, National Workman's Exhibition, S. H. Burbury, Mansfield & Son's premises, Strand, Piccadilly, Holborn and Gracechurch Street branches, Rixon & Arnold, Osborn and Kiorboe. Also work for Lord Sligo, Metropolitan Asylums Board, Crosse & Blackwell, &c.

The Kidsgrove works have not been employed to their utmost capacity during the year 1893, but notwithstanding the extreme depression of trade a fair amount of work has been completed. Amongst other contracts may be mentioned an electrical plant for Maritzburg, South Africa, consisting of a 50-unit alternator, a pair of compound engines for the same, 2 15-nominal horse-power loco. type boilers of mild steel for 120 lbs. pressure, with feed-water heater, pumps, and all necessaries for complete installation. A similar plant has also been supplied to their Sydney Branch, consisting of a 25-unit alternator, compound engines for same, with a 25 nominal horse-power loco. type boiler, of mild steel for 120 lbs. pressure. One each 6 and 10 H.P. electrical mining hoists, both self-contained and fitted with resistances and switches, and powerful lever brakes. Three sets of three-throw electrical pumps with 2½ H.P. motors. In work other than electrical, the most important contracts have been a large mechanical water-softening and filtering plant for the Corporation of St. Helens. This plant is the largest of the kind that has been made, being equal to 3,000,000 gallons per day. It consists of two mild steel Lancashire boilers, feed pumps and fittings, one horizontal steam engine, three steam and power double-acting duplicate ram pumps, one power lime mill, one large distributor, three lime-mixing cylinders and fittings, 16 mechanical filtering machines with all the necessary shafting, pipes and valve connections. A considerable amount of work has been done for the London and North Western and Great Western Joint Railways, including bridges near Hereford and Frodsham, and at Chester Station. The latter was somewhat unique, as the whole of the work usually sub-let to building contractors was done by the company. The bridge consisted of six double spans covering 11 lines of rails, three platforms, and the goods wharf and road, with four staircases fitted with patent treads. The bridge contained 120 tons of steel and iron, and the larger portion was covered with ornamental woodwork and roof. The work in hand includes four loco. type boilers, each 25 H.P. nominal, four sets of compound engines, and four 1,000 16-CP. dynamos for a central station installation, sundry small plants for colliery lighting, large colliery ventilating fan and engine, colliery pit-head gear, cages and buckets, 160 and 200 16-C.P. portable lighting plants, &c. The outlook for the new year is brighter and enquiries and small local orders are coming in more freely.

The Manchester Edison & Swan Company, Limited, in a short *resumé* of the work carried out by them in 1893, report the fitting up of the following establishments, as well as a number of others:—John L. Kennedy & Co., 47, Mosley Street, Manchester; H. Verity and Sons, 47, Mosley Street, Manchester; J. E. Waters & Co., 47, Mosley Street, Manchester; C. Lowe & Co., Chemical Works, Reddish; Sir E. Armitage & Sons, Limited, 48, Mosley Street, Manchester; Thomas Parker & Sons, 18, St. Mary's Gate, Manchester; V. B. Sandford, 33, Booth Street, Manchester; W. H. Vaundrey, 9, St. James's Square, Manchester; Capes, Dunn & Pilcher, 8, Clarence Street, Albert Square, Manchester; Geo. Macbeth & Son, 19 and 21, King Street, Manchester; T. Seymour, Mead & Co., 7, Piccadilly, Manchester; Jas. Dilworth & Son, Pall Mall, Manchester; Llandudno Pier Co., Llandudno; Guardian Society for Protection of Trade, Manchester; the Temple Chambers Co., Limited, Brazennose Street, Manchester; the Liverpool and London and Globe Insurance Co., Manchester; Blackpool Winter Gardens, Blackpool; Horrockses, Crewdson and Co., Limited, Preston; Horrockses, Crewdson & Co., Limited, Manchester; Overseers' Office, 46, Fountain Street, Manchester; Literary Philosophical Society, 46, Fountain Street, Manchester; Royal Insurance Co., 69, King Street, Manchester; Manchester Royal Infirmary, Manchester; J. H. Gartside & Co., Limited, 56, Fountain Street, Manchester; Great and Little Bolton Co-operative Society, Bolton; Boarshaw Spinning Mills, Middleton; Princes' Theatre of Varieties, Reading; John Ashworth, Broadhalgh Mill, near Rochdale; Union Bank of Manchester, Limited, Deansgate, Manchester; the Bridgeholme Wadding Manufacturing Co., Chinley; United States Consulate, 9, Mount Street, Manchester; Pendleton Co-operative Society, Limited, Broughton Road, Pendleton; Co-operative News Office, 90, Corporation Street, Manchester; Manchester Society of Chartered Accountants, Manchester; J. Whittaker, Mount Sion Bleach Works, Radcliffe; Eastern Telegraph Co., Limited, 20, Brown Street, Manchester; A. Thompson & Sons, Low Mills, Rochdale; Albion Hotel, Manchester.

(To be continued.)

Conversazione. — The annual conversazione of the Birmingham and Midland Institute took place on Tuesday, Wednesday, and Thursday, the 9th, 10th, and 11th insts. The whole of the rooms at the Town Hall and Institute used for the conversazione were lighted by the Birmingham Electric Supply Company, who also arranged in the Institute a loan exhibition of practical electric appliances. The exhibition included fittings, illustrating the application of electricity to lighting purposes, two rooms being fitted as examples, one as a drawing room by Messrs. F. and C. Osler, and the other as a dining room by Messrs. Evered & Co., Limited. A complete set of appliances for cooking and heating purposes were exhibited, and practical demonstrations were given by an experienced cook. The apparatus was supplied by Messrs. Crompton & Co. A number of small motors were shown working in connection with various types of light machinery for manufacturing and domestic purposes.

Electric Lighting of Industrial Works.—The steel and waggon works of Messrs. Dixon & Man, Limited, at Armadale have lately had the electric light fitted into the engineering, bridge building, and steel tool making departments. Messrs. Walter Dixon & Co., Glasgow, have carried out the installations. The plant consists of an improved Tyne compound wound dynamo, constructed to give an output of 7,475 watts, and is driven direct by a separate engine. The whole of the works, including the saw mill, machine shop, truck shop, smith's shop, stores, and paint shop, together with the offices and the board room, are fitted up and lit with incandescent lights of various candle-powers, amounting in all to 66 lamps, each of 16 candle-power, and 8 lamps, each of 50 candle-power, and various other groups of lights where most required. The offices have also been tastefully fitted. In the bridge building shop and in the yard three arc lamps have been placed, each of 2,000 candle-power.

Bolton Electric Lighting.—The tender of Mr. William Crumblehulme for lamp pillars has been accepted, subject to authentic information being furnished, showing that the firm pay the standard rate of wages. Pillar lamps are to be affixed in Plevna Street, Back Burlington Street, Back Willow's Lane, Dean Church Lane, Cannon Street, and Ellesmere Street. It has been decided that the ordinary accounts of the electricity department shall be kept by the existing official staff, but that "the ultimate ledger" shall be in charge of the borough treasurer's department. Telephonic communication is to be furnished between the electricity generating station and the Town Hall. At the last meeting of the Town Council a member complained that the streets were continually being opened, and recommended the erection of an underground chamber in the principal thoroughfares, so that they could get at the mains without opening the streets.

The Electrical Installation Company, Limited.—Owing to increase of business this company are extending their premises, and announce that they are moving into additional offices at 66, Victoria Street, to which number their "general office" was moved on the 8th inst. They have also started works in Pimlico, where they are manufacturing some of their specialities, *inter alia* their new patent "Vauxhall" arc lamp, their patent "Britannia" automatic projector for marine and photographic purposes, and apparatus for the application of their new system of electric heating.

This company commemorated the opening of the new year by giving a dinner to their employés, on Saturday last, at the "Royal Oak," Kennington Lane.

Guildford Electric Lighting. — At a meeting of the Guildford Town Council last week, a letter was read from the secretary of the Holloway Electricity Supply Company, thanking the council for consenting to the company's provisional order, but taking exception to the proposal to give the council the right to purchase after the lapse of 10 years only. Obviously, it was remarked, this condition did not carry out the spirit of the Act, but was, on the contrary, in direct antagonism to it. As this provision, the secretary went on to state, if insisted upon would entirely check the commencement of lighting in Guildford by private enterprise, the authority was requested to reconsider the matter. The letter was referred to a committee, with power to take such steps in the matter as they thought necessary.

Reading and Electric Lighting.—It is stated that the gentlemen who are interested in the promotion of a company for carrying out an electric lighting scheme in Reading have, during the past year, arranged with the Corporation the terms of a provisional order for this purpose, and the provisional order has been confirmed by Act of Parliament. We also understand that the company will shortly be formed, and a prospectus issued. The manager of the present electric supply station in Reading (Mr. F. F. Yeatman) states that during the year the number of arc lamps in the borough has increased some 40 per cent., while the number of incandescent lamps has been trebled, and the demand for the light still increases and cannot be met from the existing station.

Private Installations.—Mr. E. R. Dolby, C.E., of 8, Princes Street, Westminster, acting as consulting electrician for S. V. Morgan, Esq., has recently completed an installation of 137 lights at 37, Harrington Gardens, South Kensington, Messrs. G. Trollope & Sons, contractors; also about 80 lights in the Economic Life Assurance Society's offices, Messrs. Baily & Grundy, contractors; and he is now acting as consulting electrician for the lighting of "Saratoga," Forest Hill, putting in a complete installation, consisting of Crossley's Otto gas engine, Mather & Platt's dynamo, E.P.S. cells, and the equivalent of 104 lights, Messrs. Strode & Co., acting as contractors.

Dissolution of Partnership.—We are informed that the well-known Edinburgh firm of electrical engineers, Messrs, King, Brown & Co., has been dissolved by mutual consent, Messrs. A. B. Brown and D. G. Brown retiring from connection with the business. Under the name of King & Co. the business will be carried on in future, the partners being Messrs. William F. King, A. Ogilvie, and Archibald Wilson.

Messrs. Eaves, Fulwell and Butlin, trading as the Coventry Electrical Engineering Company, have dissolved partnership from December 11th last. Messrs. W. H. Eaves and W. J. Butlin will continue the business and settle debts.

Electric Light on the Stage.—The scenic effects produced by a number of miniature incandescent lamps in the performance of "Little Red Riding Hood," at Dublin Gaiety Theatre, are said by a local paper to be very charming. Little lamps are studded among the undergrowth of the trees to represent glow worms. The ladies of the ballet each wear five incandescent lamps, two on the head and three on a wand. The current for the lamps is, as usual, supplied by a small storage battery concealed in the dress. The contractors for the electrical part of the entertainment were Messrs. Porte Sykes & Co.

The Electric Lighting of Prescot.—The *Liverpool Courier* states that at a meeting of the Local Board on Wednesday last week, the surveyor reported that the British Insulated Wire Company, Prescot, who supplied the electric light to the town, had undertaken to remedy the defective lighting of the district without any unnecessary delay. The subject was further discussed, and ultimately, on the motion of the chairman, a resolution was passed holding the British Insulated Wire Company responsible for any accident which might arise through defective lighting.

Monmouth Electric Lighting.—At a special meeting of the Town Council on Thursday last week, that part of the combined scheme for electric light and drainage relating to the necessary fall in the water-course for the working of the three proposed turbines was discussed at length. It was eventually decided to procure the services of an engineer disinterested in the Brush Electrical Company and versed in hydraulic matters generally, and turbines in particular, before carrying out the electric lighting scheme for which a provisional order has been recently applied for.

Change of Address.—Owing to altered circumstances, the Nickel Company have decided to remove the head office of their commercial agency from Erdington, near Birmingham, to London. They have, therefore, been obliged to deprive themselves of the services of Mr. F. R. Martino, of Birmingham, and have appointed as sole agents for Great Britain and the Colonies, Messrs. Henry R Merton & Co., of 2, Metal Exchange Buildings, London, E.C., and 39A, New Street, Birmingham.

Portsmouth Electric Lighting.—The electric lighting committee of the Town Council are very well satisfied with the number of applications that have been received from tradesmen and others to be connected with the service which will shortly be available. St. Jude's, the leading church in Southsea, will, it is anticipated, be lighted by electricity. The new technical schools at Landport are also to be lighted with the new illuminant, as is also the clock in the lofty tower of the Town Hall.

Partnership.—Mr. James Paxman, who has for many years been the sole proprietor of Messrs. Davey, Paxman & Co., engineers, Standard Iron Works, Colchester, has taken into partnership his son, Mr. William Paxman, from January 1st. The title of the firm remains unchanged.

We understand that on January 1st Mr. Sherley Sherley-Price, son of Mr. Sherley-Price, was admitted a partner in the firm of Wheatley Kirk, Price & Goulty.

Aberdeen Town Hall and the Electric Light.—The Finance Committee have under consideration the question of the introduction of the electric light into the municipal buildings. They have remitted to the city architect, the superintendent of the gasworks, and the electrical engineer, to submit a report on the subject, with an estimate of the cost, distinguishing in the estimate the cost applicable to the different portions of the building.

Electric Lighting of Swansea Docks.—At a meeting of the Executive Committee of the Harbour Trust on Thursday, tenders were received for the electric lighting of the docks. A number of tenders were received, the competition coming from all parts of the country, and the highest tender £927. It was decided to give the contract to Mr. J. S. Brown, of Oxford Street, whose tender was £649, the contract to last for five years.

Stirling and Electric Lighting.—On Monday night the Town Council resolved not to grant the application of the Caledonian Electric Supply Company for a provisional order to supply the burgh with the electric light. It is understood the company will, nevertheless, proceed with their application, which was supported by a petition signed by 171 shop-keepers and 217 residents.

Salford and Electric Lighting.—At a recent meeting of the Town Council tenders for work connected with the installation of the electric light were accepted. In reply to questions, it was stated that the mains were to be laid, to begin with, in the thoroughfares from which the largest number of applications for the light had been received.

Battersea and Electric Lighting.—An endeavour is being made to revive the question of lighting the parish of Battersea by electricity, and the matter was discussed by the vestry on Wednesday evening.

Edinburgh Electric Lighting.—Estimates for the works in connection with the electric lighting of the city are to be advertised for. The tenders must be in before the end of the month. A portion of the High Street from the Iron Church to Jeffrey Street is probably to be lighted by electricity.

Electric Light Ladders.—Messrs. J. H. Heathman & Co. have supplied two of their electric light ladders, as described a few weeks ago in these columns, to Glasgow Art Galleries. They are also making one for Hanley lighting for use in the streets.

Electric Lighting at Whitehaven.—The surveyor to the trustees has reported that at present there are 350 16-candle-power lamps supplied with current, and applications for an additional 480 lamps, exclusive of the street and harbour lamps, have been received.

Dover Electric Lighting.—It is stated that though there was a fair demand for the shares recently offered for subscription, they were not all applied for; the necessary capital is, however, forthcoming. The company are proceeding with operations.

Situations Vacant at Wolverhampton.—The Corporation of Wolverhampton are inviting applications for the posts of draughtsman and assistant, also outdoor foreman and linesman. Full particulars will be found in our advertisements.

Heaton and Electric Lighting.—About 100 replies have been received from people in Heaton who are prepared to use electric light if the corporation will supply it at the same price as now charged in Bradford.

Bray and Electric Lighting.—The Town Clerk has been authorised to enter into necessary correspondence with electric light contractors for purchase of plant, &c.

Warminster Electric Lighting.—Preparations are almost completed for the installation of the electric light for the public lighting of the Market place.

CONTRACTS OPEN.

Cheltenham.—January 23rd. For supplying and erecting engines, dynamos and boilers at their electric light station, for the Corporation. A copy of the specification and any further information may be obtained on application to Mr. Joseph Hall, A.M.I.C.E., Municipal Offices, Cheltenham.

Edinburgh.—January 30th. Tenders are invited by the Corporation for boilers, engines, &c., &c., for the electric lighting station to be erected in Edinburgh. Further information will be found among our advertisements.

Hanley.—January 29th. Tenders are invited for the electric lighting (wiring and fittings) of the Town Hall, Free Library, Baths, Markets, &c. Also for electricity meters, main switches, and for testing and measuring instruments. Specifications and particulars can be obtained on application to Joseph Lobley, Borough Engineer.

Woking.—January 17th. For the lighting of the Woking station and Maybury ward, for the Woking Local Board. Tenders to be sent to Mr. Robert Mossop, Clerk, Woking.

NEWPORT ELECTRIC LIGHT TENDERS.

The Newport Town Council, on Tuesday last, refused to seal the electric lighting contract with Messrs. John Fowler, which had been recommended by the consulting engineer Mr. Robert Hammond. A report of the meeting appears in, another part of this issue, but for present purposes we will briefly set forth a few facts. A short time ago the council invited tenders for supplying plant for an alternating current station, nearly 60 contractors replying to the invitation. In dealing with these tenders, Mr. Hammond drew up a report for the Electric Lighting Committee, which is a splendid example of the art of mystification. The report sets forth most elaborate and questionable details of boilers and steam engines; it is also sectioned and sub-sectioned in a manner that ought to make a conscientious committeeman regret that he was ever born. Still we are willing to look upon the form of this report as a foible of the consulting engineer, and as such, to be lightly dealt with. The all-round tenders of the firms which were apparently retained for special consideration were those of Messrs. Fowler & Co. (£23,384), and Messrs. Crompton (£20,780). After considering the matter in some 50 pages of report, Mr. Hammond favours the tender of Messrs. Fowler.

It will be seen that a great disparity exists between the

prices of what were the two lowest tenders, and it would have apparently needed some cogent reasons for recommending that of Messrs. Fowler in preference to that of Messrs. Crompton. Mr. Hammond has, however, proved equal to the task, and without advancing any special arguments, does not hesitate to say that Messrs. Fowler's tender is the better one. The ground on which Mr. Hammond urges the adoption of this tender is that Messrs. Fowler have had great experience of alternating current work. It was unnecessary, and decidedly unfair, for the consulting engineer to go out of his way to say that Messrs. Crompton had had only experience of low tension, because it was speaking without a real knowledge of the facts; but when he says that Fowlers have had a great deal of experience in alternating work, we must take exception to his statement. What is Messrs. Fowler's experience of alternating current stations? They have supplied engines to most of the stations with which Mr. Hammond has been connected, but the whole of the electrical plant has been supplied either by Mr. Hammond's late firm, or the Leeds and London Electrical Engineering Company. The report shows that Fowler & Co. will really use alternators made by the Leeds and London Electrical Engineering Company, and if Mr. Hammond had said that the officials of this company had had great experience of alternating stations, one could not have objected.

It may be urged that Messrs. Fowler are intimately connected with this company, but for the matter of that Mr. Hammond, until quite recently, was as closely connected. It must be confessed that the Electric Light Committee, when considering the tenders, exercised peculiar judgment, and the council apparently thought so, for they referred the matter back for further consideration. We note that Mr. Hammond's report is dated December 21st, 1893, from 117, Bishopsgate Street, yet we find that the committee actually sat on the same day for the purpose of deciding upon this report; and, what is more, they actually adopted it, and the Parliamentary Committee next day approved of this. It can be fairly assumed from this that the majority of the committeemen never read the report, and the fact that a member of the committee (Mr. Parnall) was under the impression that Cromptons had submitted a low-tension scheme, lends credence to our suggestion. Mr. Hammond explained his position in a clever speech, but to electrical engineers his remarks are absolutely unconvincing. He dwelt upon his experience of fifteen years, but what has Mr. Hammond accomplished during this long period? He has laid down a few stations on the high tension alternating systems, none of which, we think, can yet be considered successful, and it is not too much to suggest of some that they are rather the reverse.

It is not necessary to discuss at the present moment whether a high tension or a low tension system would have been best for Newport, but before concluding we must repeat that, considering Mr. Hammond's recent connection with Messrs. Fowlers, he has not advanced anything like sufficient reason for adopting this firm's tender in preference to that of Messrs. Crompton.

NOTES.

Walsall Electric Lighting Scheme.—The Town Council last week selected a site for a central station, and have resolved to make application to the Local Government Board, that the loan of £19,650 for the proposed scheme of electric lighting be increased to £21,900, so as to include the sum of £2,250 for the land referred to.

Belfast and Electric Lighting.—The City Council being tired of the continued delays in pushing forward the electric lighting operations, have, by 17 votes to 16, taken the management out of the hands of the Gas Committee. The Town Clerk last week submitted Prof. Kennedy's reports on the tenders which had been sent to him, and was instructed to furnish a copy of this report to each member of the new electric lighting committee for consideration at next meeting. The committee proceeded to the site of the new central station, and, it is said, they gave orders for the ground to be cleared at once.

Bermondsey Vestry and Electric Lighting.—It having become necessary that steps be taken to ensure the more efficient lighting of certain parts of the Bermondsey district, a member of the vestry proposed that they consider the practicability and advisability of lighting the baths, Town Hall and library with electricity. The other members, however, would have none of it.

The Niagara Scheme.—Prof. Jamieson's letter in our last issue confirms our views on the engagement of experts; the men he refers to are specialists in the highest sense of the word, and were all fully trained by long practical experience. Professors of naval architecture are men of experience in naval architecture, but professors of physics, or mechanics, or engineering, are very seldom men of experience in electrical engineering; or, to make the case parallel, men of experience in "*dynamo-electric machine architecture.*" The naval architects referred to do not require to travel about the Continent to gather information. They take the initiative themselves, and lead the world in shipbuilding, while some professors, who pose as electrical engineering experts, follow behind the practice of the leading electrical engineers, and have never in any case taken the first steps themselves. If they were specialists and professors in electrical engineering, would this following of practice, instead of leading, be necessary on their part?

The Buda-Pesth Central Station.—We have already referred to the central station carried out at Buda-Pesth by the Nuremberg Electrical Company, formerly Schuckert and Co. Two months ago the station, which is carried on by the local gas company, began to supply current. The present plant consists of two sets of machinery of 150 H.P. each, which, along with a battery of accumulators of the capacity of 2 × 1,500 ampères, generate current sufficient for 6,000 lamps. This number has been already taken up. The main plant, capable of supplying 150,000 lamps, will probably be ready by February of next year. The numerous demands for current have induced the gas company to contemplate for the present year the construction of two additional sub-stations, and a further extension of the machinery. This station is the only one in the world in which the multiphase current system is employed on a large scale. The alternating current machines are arranged for 25 periods per second at a tension of 2,000 volts. Since the commencement of the supply, there has been no interruption whatever.

Electric Traction.—We are informed that Mr. Rankin Kennedy has discovered a new method of electric traction, whereby the great drawback to the present methods is said to be overcome. The losses in, and the great size of the plant required for electric traction as presently carried on, are pointedly referred to in the *Engineer* of December 15th, after reviewing the proposed regulations of the Board of Trade in the following paragraph:—"It must, however, be remembered that the electric tramway engineers are not yet prepared, even with the fairest possible and most encouraging regulations, to give an electric tramway service that will meet the requirements of most English towns. There is not yet a really satisfactory system of underground conductor, and the overhead system is not liked, although much that has been said against it is only partly true. But so long as the electrical engineer finds it necessary to provide for current for motors of from 25 to 40 horse-power on each 2-horse tramcar, so long will there be difficulties, and so long as these enormously powerful motors are required for merely starting cars, or getting them up an incline on which four horses would haul them, it cannot be said electrical engineers are ready for good commercial tramway work, regulations or no regulations." The 25 to 40 horse-power motor required on the car is not the whole of the trouble; generators, conductors, and all other apparatus must be provided on a correspondingly large scale; any method which would reduce the motor would also reduce the whole plant in the same proportion. The new method referred to proposes to do the work with a motor from 5 to 10 horse-power. Such a reduction would go a long way towards a satisfactory underground system. The new method is being submitted to American experts, who have much more experience in electric traction than those in any other country.

Newport and Electric Lighting.—A Local Government inquiry was held on Wednesday last week into the application of the borough council to borrow £28,000 for electric lighting purposes.

The Telegraph in Denmark.—The Danish telegraph system at the end of 1892 had a length of 4,604 kilometres of line and 12,894 kilometres of wire, serving 389 offices. The number of telegrams dealt with in 1892 was 1,636,971. The total receipts in that year were 1,145,016 francs.

The Telegraph in Sweden.—The Swedish Telegraph system at the end of the year 1892 had a length of 8,588 kilometres of line and 23,387 kilometres of wire, serving 442 offices. The number of telegrams dealt with during 1892 reached a total of 1,866,823. The total receipts in that year were 1,819,518 francs, and the total expenses 1,648,642 francs. At the end of 1892 the telephonic system consisted of 5,613 kilometres of line, and 29,528 kilometres of wire. The number of subscribers was 27,838 with 695 central stations.

Telegraphy in France.—The "Digest," New York *Electrical World*, takes from *L'Electrique* the following statistics of telegraphy in France for the year 1892:—There were 103,280 kilos. of lines, made up of 318,733 kilos. of wire; 11,081 stations; 17,607 telegraphic apparatus, of which 12,123 are Morse, and 768 Hughes. The number of telegrams sent was almost 35,000,000. Comparative statements show that Germany leads in length of wire and quantity of apparatus; Great Britain comes next; and lastly, France, almost in the ratio of the populations. Statistics are also given for the French colonies.

The Committee of the Exhibition of 1900.—A decree issued by the Minister of Commerce, Industry, and the Colonies, nominates the following members for the committee of the Exhibition of 1900 at Paris:—Dietz-Monnin, de Freycinet, Griffe, Poirrier, Jules Simon, Spuller, Tolain, Waddington; Humbert, Chautemps, Denys Cochin, Lockroy, Mesureur, Trélat, Burdeau, Roux, Etienne, Krautz, Isambert, Méline, Legrand, Raynal, Sibille, Siegfried; Chanchet, Rousseau, Caron, Duval, Levrand, Lopin, Maury, Muzet, Santon Shauss; Berthelot, Mascart, Say, de Tocqueville, Guillaume, Daumet, Garnier, Vaudremer, Bœowildwald, Rane, Mezières, Hervè, Bourdet, Duval and Schneider.

Central Stations in Germany.—The following statistics of the central stations of Germany (with the exception of Bavaria and Wurtemburg) have been prepared by Dr. Stephan: There are 4,974 installations, of which 4,884 are for electric lighting; the number of incandescent lamps is 852,263; the number of arc lamps is 44,588. Of the remaining 90 installations, 22 are for electrolytic purposes, and 68 for power transmission; 328 use alternating currents, 148 direct and alternating currents, 5 three-phase currents, and 4,493 direct currents; in 131 the lines are underground, and in the others they are mostly overhead. Uninsulated wires are used in 2,370 of the installations. These figures are taken from the N.Y *Electrical World* "Digest."

The Longest Circuit in the World.—The New York *Telegraph Age* says that on December 3rd, President Cleveland's message was transmitted direct from the New York bureau of the United Press to San Diego, Cala., *viâ* the Postal, Canadian Pacific, and the Pacific Postal telegraph lines. There were 12 repeaters in the circuit, situated as follows:—Albany, 150 miles; Montreal, 343 miles; Sudbury, Ont., 444 miles; Fort William, Ont., 553 miles; Winnipeg, Man., 426 miles; Swift Current, N.W.T., 511 miles; Donald, B.C., 513 miles; Vancouver, B.C., 458 miles; Portland, Ore., 367 miles; Ashland, Ore., 316 miles; San Francisco, Cal., 402 miles; Los Angeles, Cal., 473 miles. San Diego is about 122 miles south of Los Angeles, which made the total length of the circuit 5,080 miles, which was without doubt the longest circuit ever successfully worked for any length of time. The message consisted of 5,211 words, and the time occupied in transmitting the same was 3 hours and 42 minutes.

Electric Tramways in India.—According to the *Madras Times*, the Mayor of Colombo cherishes the hope of getting local tramways worked by electricity.

The Telegraph in Norway.—The Norwegian Telegraph system at the end of 1892 had a length of 7,863 kilometres of line and 15,548 kilometres of wire, serving 178 offices. The number of telegrams dealt with during 1892 reached a total of 1,660,370. The total receipts in that year were 1,747,115 francs, and the expenses 1,679,363 francs.

Electric Tramways at Hartlepool.—A deputation, on Thursday last week, left the Hartlepools for Leeds, for the purpose of inspecting the system of running tramcars by electricity by means of overhead wires. It is proposed to utilise the existing tram lines between the Hartlepools for electric cars, a syndicate having been formed with that view. The Mayors of the two boroughs accompanied the deputation.

Wolverhampton Electric Lighting.—A Local Government Board enquiry was held on Thursday last week regarding the application of the Town Council for permission to borrow £30,000 for electric lighting purposes. It is at present intended to light only half the town as an experiment. There would be 40 arc lamps, 20 of which would be extinguished at midnight, and the other half later on. The estimated dead expenses were £3,300, and the minimum number of lights required to be used annually would be equal to 193,600 units, at 6d. per unit. After hearing the evidence, the inspector proceeded to view the site of the proposed works.

Gas Explosions.—Several employés of the gas company were working at a manhole of the National Telephone Company in Church Street, Sheffield, on Monday last, where a 6-inch gas main had been burst by the frost, when an alarming accident occurred. One of the men was using a crowbar to prise open an iron lid when a spark ignited the gas with which the chamber was filled. A loud explosion took place, the heavy lid being blown high into the air and descending upon one of the workmen, who was severely injured, and was conveyed in a cab to the hospital.

A similar explosion to that at Sheffield occurred on Monday at Newcastle, when another of the National Telephone Company's employés was slightly injured while engaged at work in Grey Street.

Maximum Efficiency of Arc Lamps.—Writing further on this subject, Mr. Henry S. Carhart, in the *Electrical World*, says:—"In the *Electrical World's* 'Digest of Current Technical Electrical Literature,' of December 2nd, Mr. Crompton, of London, is represented as criticising my Congress paper on 'Maximum Efficiency of Arc Lamps with Constant Watts.' Mr. Crompton's interesting letter is in the London Electrical Review for November 10th. I do not understand Mr. Crompton's letter in this way, for I agree with him. He called attention to the conclusions of the editorial abstract in the Review, and gives the results of his own experiments without having read my paper. The only point that I tried to make in my brief paper is this, that the candle-power or efficiency of an arc lamp is not determined by the number of watts expended on it, but upon the way the watts are made up; and I distinctly say that the results obtained were with one kind and size of carbons. The opinion is also expressed that with larger carbons the current would probably be larger and the volts less for maximum candle-power with 450 watts. This is exactly what Mr. Crompton has found. With the larger upper cored carbon of superior quality he gets higher candle-power; and the voltage is 42 or 43, while the current is about 10·6 ampères. I call attention to this point for the purpose of emphasising the conclusion that higher efficiencies are obtained by using a larger cored carbon for the upper one, and a smaller solid negative. The day of cheap and inefficient carbons should soon be passed. Mr. Crompton's results are fully 50 per cent. better than I obtained with such carbons as are in common use in this country. The moral is that wherever a highly efficient service is desired instead of merely a cheap one, it is of the utmost importance to use the best carbons obtainable."

The Electric Light at Brighton.—By 19 votes to 6, the Brighton Town Council last week adopted a report from the Lighting Committee recommending the expenditure of an additional £35,000 in electric lighting. The Brighton and Hove Electric Light Company is to be bought up for £5,000, and other portions of the town hitherto not dealt with are to receive cables for the purpose of supply. This is the third big extension the Corporation has made.

The New Pacific Cable.—The *Canadian Gazette* in last week's issue again comments upon the necessity of the new cable to which it has referred so many times of late. Our contemporary calls upon the Government to take in hand the matter of this required cable service. "The Canadian and Australian colonies are anxious to be connected by an all-British cable." A representative of the *Canadian Gazette* interviewed Mr. Sandford Fleming while he was in London regarding the feeling among those in the colonies interested in the proposed line of communication.

The Charing Cross, Euston and Hampstead Railway Company.—This company, which was incorporated last year with powers to construct an underground electric railway from Charing Cross to Hampstead, with a branch line to Euston, have deposited a Bill for next session of Parliament, under which the company seek for powers to acquire, in addition to that authorised last year, important properties situated in the Strand, Villiers Street, Buckingham Street, Oxford Street, High Street, Camden Road, Kentish Town Road, Melton Street, Drummond Street, and Cardington Street. Other properties proposed to be acquired include a portion of the recreation ground forming part of the disused burial ground of St. Martin's-in-the-Fields, and a portion of Meux's Brewery in New Oxford Street.

Phase Meter.—Prof. Puluj has designed an instrument for use with alternating currents, which consists of two identical coils, each provided with a core, in front of which is a flat spring carrying a small piece of iron, to which is fixed a mirror. An alternating current passed through either coil will cause its mirror to vibrate, and by placing two of these so that the springs are perpendicular to each other, and by reflecting the same beam of light from the mirrors, an elliptical image will be produced, from the shape of which the phase may be calculated from formulæ given by Prof. Puluj. This is described in the *Elec. Zeit.*, and abstracted in the "Digest," N.Y. *Electrical World*. We may observe that a similar method for the measurement of alternating currents was tried by Mr. Rollo Appleyard some six months ago; it was, however, found quite impracticable, owing to the vibration frequency of the spring. Prof. Puluj claims to have met this difficulty by a preliminary "tuning" of the springs. A twisted strip with a single half-turn might possibly be made to replace the two springs necessary for the phase-meter, in which case only one mirror would be necessary.

"There's Many a Slip, &c."—Says *Lightning*:—"We enter the New Year with a determination to continue the crusade against bad work, bad logic, and bad finance." In another paragraph it gets into a contemplative mood:—"At the opening of its fifth volume, it is pleasant to be able to reflect how thoroughly the efforts of *Lightning* have been appreciated, and how persistently it has 'stuck to its last.' It has left to the *Electrician* the care of the scientific problems involved in the industry; and to the Electrical Review the destructive criticism which is so easily indulged in." After such high praise from the contemporary which says it "has no more interest in Mr. Hammond than in any other member of the profession, and that he has no interest in, or control over, the paper, its policy, or its views," it is odd to find in the last issue of the *Electrician* a letter from a member of the *Lightning* staff, informing the editor that its leading article of December 22nd, on the Institution of Electrical Engineers, is an example of "destructive criticism." Perhaps a slight confusion of titles has occurred, or is it only bad logic? It seems not unlikely that the new editor of "the Popular and Business Review of Electricity" will over-do the zeal of the possessor of a new broom; for, surely in making such definite statements about the independence of his journal, he must be speaking of some pre-historic period.

Electric Light and Destructors at Bury.—The Town Council have instructed the Electric Lighting Committee to consider the desirability of utilising the heat from the destructor for generating heat for the electric lighting machinery.

City and Guilds of London Institute.—A special course of three lectures, on "Governing Arrangements of Engines," by R. G. Blaine, M.E., Assoc.M.Inst.C.E., &c., are to be delivered on Thursday evenings, commencing January 18th.

Explosions in Main Boxes.—Some explosions in the electric light main boxes of the City Company occurred on Monday morning last in London, shortly after 10 o'clock. Two of the pavement covers, one situate at the corner of Creed Lane and Ludgate Hill, and the other in St. Paul's Churchyard, were blown into the air with teriffic force. The cover in St. Paul's Churchyard fell to the ground, breaking a large stone flag into fragments, although the stone and metal plate both remained intact. The other cover, which is reported to have risen to a height of 40 feet, was broken into innumerable pieces upon striking the ground. A boy who was standing near the second cover was thrown into the roadway, and was taken to St. Bartholomew's Hospital, having received serious injury.

At Tuesday's meeting of the Commissioners of Sewers, a question was asked regarding these two explosions, calling forth a reply to the effect that Mr. W. H. Preece had been written to and asked for a report on the subject. A further communication had been addressed to the electric lighting company, who had replied, stating that the explosion was due to an accumulation of gas in the boxes in question, but how it was lighted did not transpire.

Terrestrial Magnetic Phenomena: their Variation and Cause.—It is often complained that magnetic observations are persistently accumulated without any attempt being made on the part of the meteorological and other authorities to systematise the results, to say nothing of interpreting them. Now, although every clear-minded scientist will concede that no useful nor reliable generalisations can be made until a sufficiency of data have been collected, it must be admitted that the desirability of exercising the function of generalisation appears often to be lost sight of; observations are mechanically made and results accumulated by those who are officially responsible for these duties, but it appears to be none of their duty to go farther. We disapprove of hasty attempts to construct theories; premature hypotheses have always retarded the growth of knowledge; nevertheless, more might be done in this country in the direction recently pursued by Prof. F. H. Bigelow in America. In a paper read at the Congress of Astronomy and Astrophysics at Chicago, and reprinted in the October number of the official publication of the Congress, the professor gives the first communication of some results deduced from the magnetic observations collected by the U.S. Weather Bureaux during the last two years. The investigation consisted partly in the construction of a model formed by wires stuck in a 30-inch globe to represent in magnitude and direction the resultant of the magnetic force as observed at 30 different observatories at each hour of local time, the local hour being treated as longitude on the globe. On the assumption that variation in earth-magnetism is due to position with respect to the sun, the model shows the effect of the sun on the whole of the earth at any instant. Some peculiar arrangements of the symmetry of these forces thus exhibited are described, and the professor claims that "a study of the model offers a satisfactory explanation of all complex phenomena that have been so fully described in the literature of magnetic observations." The remainder of the paper is particularly interesting to the solar astronomer. The mean magnetic force, if we may so call it, for each day, has been formed for several stations, and the residuals from the normal magnetic force (found by taking an annual daily mean) tabulated for each day for 12 years, 1878—89. The professor claims that the table shows a period of 26·82 days, which agrees closely enough with the period of rotation of the sun's equator as formed from observations of sun spots, from which it seems to be assumed that magnetic phenomena are caused in part, at least, by the solar rotation.

Brussels Electric Lighting.—It is said that consumers are combining in an appeal to the municipal authorities regarding the high charges made for electric current.

Swansea Electric Lighting.—An electric lighting scheme, under the council's consideration, is expected to cost £30,000. Mr. Manville is the consulting engineer.

Government and the Telephones.—It is understood that there is now no prospect that the agreement between the Government and the National Telephone Company will be laid on the table in the course of the present Session.

Bath Electric Lighting.—The repeated complaints which have from time to time been made at Bath regarding the electric lighting were added to on 5th inst., when, owing to some cause or other, the lamps in the upper portion of the city could not be lighted. Much inconvenience to consumers resulted.

Rangoon and Electric Lighting.—A firm has offered to introduce the electric light into Rangoon without expense to the public, and to give three times the present amount of illumination to the streets at the present cost of oil lighting to the municipality. But it wishes to have a monopoly of the electric lighting for a certain number of years, and to reimburse the cost of introductions by the fees it would levy for supplying electric lights to private houses.

Electrical Euthanasia.—Electricity is now being utilised for killing homeless dogs and cats at Hartford, Connecticut, U.S.A. In the rear of the police station there is a cage just large enough for a dog to stand in, fitted up with electrical connections. According to the *British Medical Journal*, the fore feet of the animal rest upon one electrode, and his hind feet upon another, and when he is in position an electric current is switched on, and he is put to death on the same principle as criminals are executed.

Eccles and Electric Lighting.—A member of the Council last week recommended that steps be taken to carry out the powers granted to them by their electric lighting order. He said in the course of his remarks, that if they supplied something like 2,000 to 3,000 lights, there would be a loss, but with 6,000 lights there would be a profit, and with 13,000 lights they could make a profit of about £1,000 per annum. The matter is to be fully inquired into by a committee.

In Memory of Dr. Joule.—Mr. W. H. Bailey, Mayor of Salford, and head of the firm of W. H. Bailey & Co., has notified the Manchester and Salford Town Councils of his intention to institute a fund for providing a silver medal annually, to commemorate the discoveries of Dr. James Prescott Joule, to be competed for by present or past students of the Salford Technical School, the City of Manchester Technical School, and students or associates of the Institute of Civil Engineers under the age of 25 years.

Electric Light at St. Paul's Cathedral.—A week or two ago we announced that the advisability of lighting St. Paul's by electricity was receiving consideration. On Monday last the committee dealing with the matter carried out some experiments for the purpose of testing the advantages of both the arc and incandescent systems of lighting, with the assistance of the City of London Electric Lighting Company. The company laid on temporary wires for the occasion, and lamps were fixed in various positions round the walls beneath the dome. The *City Press*, concluding a short article on the subject, says:—"Nothing was absolutely decided upon, but it would seem that any system which should be adopted, if electric lighting is finally determined upon, must include a number of standards beneath the dome carrying, in all likelihood, incandescent lamps. The great difficulty in carrying out any system of lighting is to afford sufficient illumination for the worshippers to be able to read the service and hymn-books, whilst, at the same time, the preacher and reader are not confronted by a blinding glare which would be altogether intolerable. As matters stand, no decisive result has at present been arrived at, but we believe further experiments are to be carried into effect."

Railway Station Lighting.—Taunton Great Western Railway Station is being altered and improved, and, in all probability, electric lighting is to be the illuminant.

Institution of Electrical Engineers' Students' Meeting.—On Friday, January 19th, at 28, Victoria Street, Westminster, a paper is to be read on "Multiphase Currents and their Applications," by C. V. Drysdale, student.

Swindon Lighting.—The Swindon New Town Local Board recently advertised for tenders for lighting the town by gas, oil, or electric light. Gas has now been decided upon, and the New Swindon Gas Company have the contract for twelve months.

Leakage Accident at Bournemouth.—An accident, causing the death of a bus-horse and a good deal of furious yelping by a couple of dogs, happened at Bournemouth on Monday afternoon. A leakage from the electric light wires underneath the road is said to be responsible for this. Major Cardew held an enquiry regarding the accident on Tuesday on behalf of the Board of Trade.

South Staffordshire Tramways.—The South Staffordshire Tramway Company have given notice to the West Bromwich Town Council of their intention to promote a provisional order to enable them to adopt cable traction through the borough.

Royal Institution.—Prof. Charles Stewart will, on Tuesday next, January 16th, begin a course of nine lectures on "Locomotion and Fixation in Plants and Animals." The Friday evening meetings begin on January 19th, when Prof. Dewar will deliver a discourse on "Scientific Uses of Liquid Air."

A Contemporary and the Institution.—A respected contemporary has been rather severe on the I.E.E. the last week or two, but without any justification in its present action. So far from treating the Board of Trade Draft Regulations carelessly, the whole council was appointed a committee on the subject, and is dealing with the matter with the greatest care.

The Passage of Electric Wave-Trains through Layers of Electrolyte.—The attempt to compare the resistances of electrolytes with rapidly alternating currents, by utilising for that purpose electric radiation, was first made by Prof. J. J. Thomson, in 1888 (*vide Proc.* Roy. Soc. xlv., p. 269). In this way the conductivities of several different solutions were compared, and the ratios found were approximately those of the conductivities determined by ordinary methods; but the determinations were not absolute. This line of research was again taken up last winter by Mr. G. U. Yule, in the Physical Institute of the University at Bonn, and a preliminary note was published by him in the *Proc.* Roy. Soc., Vol. liv., p. 96, May, 1893. After several attempts to improve upon Prof. Thomson's method, the following was adopted:—The waves were propagated along, or between, a pair of long wires instead of being allowed to scatter in all directions through space; a certain length of these wires was then immersed in an electrolyte, and the ratio determined in which the wave-trains were weakened by their passage through this absorbent layer. Measurements could then be made fairly accurately by means of an electrometer. It would have been easy from a series of observations to calculate the conductivity of the electrolyte used if the change in the transmitted intensity were only a consequence of absorption. But the matter proved not so simple. As the thickness of the absorbent layer increased, the transmitted intensity, so far from decreasing logarithmically, did not continuously decrease at all, but decreased and increased periodically. The effect was obviously analogous to the interference-phenomena of thin plates by transmitted light; independently of any slight absorption a layer a quarter wave-length thick transmitted a minimum a half wave-length thick a maximum, and so on. This disturbance made the matter too complex to permit of an exact determination of the conductivity, but its intrinsic interest was quite sufficient to warrant further investigation, and in the December number of the *Phil. Mag.* a detailed account of Mr. Yule's experiments is given.

Church Lighting.—Widford Church is about to be lighted by electricity.

High and Low Tension.—The comparison between high-tension and low-tension systems made by us last week has been objected to on the grounds that no account was taken of the relative size of the different stations. Our critic wished apparently to show that although there were more high-tension stations, many of them were small ones and could not compete in size with the low-tension stations. Perhaps it will be more satisfactory if we give the approximate capacity in 8-C.P. lamps of the rival system. The high-tension stations have a capacity of about 858,000, and the low-tension 633,000. There can be no possible objection to this comparison; at the same time it really places high-tension in a better light than our previous figures did. Speaking of comparisons between different systems, we fail to appreciate the unmistakeable jealousy which adherents of one method have for any other. It seems to us that the advocates are primarily interested in the advance of electric lighting, and no matter what system went ahead fastest, they should rejoice.

Fast Speed Working on Cables.—Seeing the high price which might be demanded by, and which probably would be allowed to, the successful inventor of a system of increasing the rate of signalling on long submarine cables, it is not surprising that there are many working in the field, but it is surprising that some steps are not taken to prove the value of the numerous devices which are confidently put forward, and, in some cases patented, as means of bringing about the desired result. A favourite idea seems to be that of dividing the cable into two or more sections and connecting the same by repeaters. So far the arrangement is sound in principle, and, indeed, also in practice, as is evidenced by the adoption of the same on the fast speed circuits of the postal telegraph system. Now it would at once occur to one that the substitution of an induction coil repeater for the mechanical apparatus would be such a simple matter that a trial of the same might be made, and the result would go far to settle the question whether such an arrangement were really of any use or not. As a matter of fact, such an arrangement has been tried, and that not recently, and the result has shown conclusively that *no gain in speed whatever is obtained.* The result of a very large number of experiments which have been carried on for a number of years, has shown that all arrangements of the kind effect no improvement in working unless, indeed, the working arrangements at the *ends* of the line are defective, in which case under some conditions a small improvement is obtained, which improvement, however, is better obtained by properly arranging the terminal conditions. It is perfectly well known that an induction coil repeater on a telephone line produces a marked deterioration in the speaking; in no single case has an improvement been effected. Founded on incomplete, if elaborate, theories propounded by those who have had no experience whatever of practical telegraphy, in no single case have such theories been proved to be even approximately near the truth.

CITY NOTES.

The National Electric Supply Company.

WE have much pleasure in publishing the following letter from Mr. Thomas Cross, the secretary of the National Electric Supply Company, with reference to our remarks on the company's accounts:—

"Dear Sir,—We note your article in this week's REVIEW with reference to our accounts for the year ending December, 1892. We wish to point out, however, that you are not correct in stating that a loss in distribution of 20 per cent. was incurred on a low tension three-wire system. Although the mains were designed for a three-wire low tension system, we did not commence to use them in that manner until August 1st, 1893. Previous to that time the two outside conductors were used as the outgoing mains, and the smaller section, or middle conductor, was used as a common return for both sides, thereby causing the aforesaid loss in distribution.

We are, Yours faithfully,

THE NATIONAL ELECTRIC SUPPLY COMPANY, LIMITED,

THOMAS CROSS, *Secretary.*"

The foregoing sufficiently explains the great loss in distribution, and as we anticipated, the next accounts should show considerable economy.

Company of the Place Clichy Sector, Paris.

THE general report recently presented at the general meeting of the company of the Place Clichy Sector, Paris, contains some very interesting information. We will mention a few facts:—A new Corliss vertical engine of 500 H.P. has been installed, and has brought the total motive power up to 2,450 H.P. A second battery of Laurent-Cély accumulators of 175 H.P., and a battery of Tudor accumulators of 500 H.P., have been brought into requisition. The total maximum power, therefore, is now brought up to 3,125 H.P. The canalisation, which was 33 kilometres at the end of last season, is extended to 45 kilometres. The armoured cables encased in lead, which are laid directly in the ground, have given satisfaction from all points of view. The number of consumers is 743; the public lighting comprises 678 10-candle lamps, and the private lighting 45,085 10-candle lamps. The public lighting includes six arc lamps of 15 ampères in the Rue St. Lazare, 26 arc lamps of 10 ampères in the Avenue de Clichy, and eight arc lamps of 10 ampères in the Square des Batignolles. The cost of the additional plant was 1,596,589·95 fr. The working expenses amounted to 391,204·95 fr., including the cost of labour, coal, and water, and sundry other expenses. The receipts amounted to 50,721·55 fr. for public lighting, 804,991·30 fr. for private lighting, and 54,232·75 fr. for the interest and maintenance of the branch lines and meters, bringing up a total of 909,945·60 francs, showing an increase of 257,972·60 fr. over last season. The net product of the working, *i.e.*, the difference between the receipts and the expenses, was, therefore, 518,740·65 fr. From this sum must be deducted, first, the expenses of the directors, 10,500 fr.; the interest of the bonds up to June 30th, 117,952·20 fr.; the interest on the current accounts, 30,034·75 fr.; 5 per cent. off the accounts of the consumers to be paid to the City of Paris, 40,547·50 fr., and a sum in virtue of a share in the profits 12,430 fr., bringing up the total to 211,464·50 fr. Thus the sum left available was 307,276·15 fr., the employment of which was regulated as follows at the general meeting:—Reserve fund, interest on, and 5 per cent. on the profits of the year, 15,807·95 fr.; sinking fund, 131,468·20 fr., and dividend at the rate of 4 per cent., 160,000 fr.

Allgemeine Elektricitäts Gesellschaft.

THIS company (formerly known as Schuckert & Co., of Nürnberg) has issued its annual report for the business year, July 1st, 1892, to June 30th, 1893. The sole agents in this country are the Electrical Company, Limited. The net profit distributed during the past ten years has been 9,148,500 marks, or an average dividend of 7·62 per cent. The company now employs 2,898 officials and workmen, and the total capital of the undertaking is 75,000,000 marks. They have now 14 street tramways in action of the length of 150 kilometres. They have in project an underground electric railway in Berlin. The general demand for glow lamps remains, the report states, unfavourable; still their sale has increased by more than 30 per cent., as compared with the previous year, and the profit has been satisfactory. The company seems to be connected with certain subsidiary companies, such as the Joint-Stock Company for Bronze and Zinc Castings (J. C. Spinn & Co.), and the Electrical Company, Limited, of London, which is described as "opening up the English market for our products." A sum of 6,799·77 marks has been written off for the costs of patents and 2,462·74 marks for expense of litigation. Among the patents held by the company is one for the production of aluminium wares, and it is also concerned in the Hagen company for the manufacture of accumulators.

Port Beira Pier, Tramway and Telegraph Company, Limited.—This company has been formed with a capital of £150,000, in £1 shares, which are now offered for public subscription, to acquire certain privileges and concessions granted by the Mozambique Company for the construction of piers and landing stages, tramways, telegraphs and telephones in the port and town of Beira. The subscription list opened on Tuesday, and closed on Wednesday.

The Direct United States Cable Company, Limited.—The board have resolved upon the payment of an interim dividend of 3s. per share, free of income tax, being at the rate of 3 per cent. per annum for the quarter ending December 31st, 1893, such dividend to be payable on and after the 24th inst., carrying forward £3,080 10s. 10d.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending January 7th, 1894, amounted to £990; week ending January 8th, 1893, £998; decrease, £8; total receipts for half-year, 1894, £990; corresponding period, 1893, £998; decrease, £8.

The Great Northern Telegraph Company. The traffic receipts in December 1893, were £20,800; January 1st to December 31st, 1893, £269,200; corresponding months, 1892, £266,400; corresponding months, 1891, £282,600.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending January 5th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company Limited, were £3,087.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Issue.	Name.	Stock or Share.‡	Closing Quotation January 3rd.	Closing Quotation, January 10th.	Business done during week ended January 10th, 1894. Highest.	Lowest
184,500*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Rogd. and to Bearer	100	99 —102 xd	99 —102 xd	...	...
1,134,640*l*	Anglo-American Telegraph, Limited	Stock	43 — 45	42 — 44	...	...
2,932,680*l*	Do. do. 6 p. c. Preferred	Stock	81 — 82	79½— 80½	81⅝	80
2,932,680*l*	Do. do. Deferred	Stock	7⅛ - 8	7 — 7⅛	7⅛	...
130,000	Brazilian Submarine Telegraph, Limited	10	11⅜— 12¼	11½— 12	11⅝	11 9/16
18,700*l*	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	107 —111 xd	107 —111 xd	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	2⅜ — 2⅝	2⅜ — 2⅝	2 9/16	2⅜
75,000	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2 — 2¼	2 — 2¼	2⅛	2 1/16
125,000*l*	Do. do. 4½ per cent. Debenture Stock	Stock	105 —107	104 —106	104	...
20,510	Charing Cross & Strand Electricity Supply Nos. 1 to 6, 215 to 718, and 10,001 to 30,000	5	4½— 5	4½— 5	...	...
44,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	2 — 3	2 — 3	...	...
630,000*l*	City and South London Railway	Stock	28 — 33	28 — 33	...	...
40,000	City of London Elec. Lighting Co., Ltd., Ord. 40,001-80,000 ...	10	11¼ - 11⅜	11¼— 11⅜	11⅜	...
20,000	Do. do. 6 p. c. Cum. Pref., Nos. 1 to 20,000	10	13 — 13½	13 — 13½	13 7/16	13⅛
10,000,000$	Commercial Cable, Capital Stock	$100	130 —140	130 —140	...	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	10/-	1/16— 3/16	1/16— 3/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	4 — 4½	4 — 4½	...	...
50,000*l*	Do. do. 5 p. c. 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	96 —101	96 —101	...	...
16,000	Cuba Telegraph, Limited	10	11½— 12½	11½— 12½	..	...
6,000	Do. do. 10 p. c. Preference	10	18 — 19	18 — 19	18	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
6,000	Do. do. 10 p. c. Preference	5	8½— 9½	8½ - 9½	...	...
60,710	Direct United States Cable, Limited, 1877	20	11⅜— 11⅝	11½— 11⅝	11½	11 3/16
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	15 — 15½	15 — 15½	15½	15
70,000	Do. do. 6 p. c. Preference	10	15⅝— 16¼	15⅝— 16¼	16 1/16	15⅝
105,900*l*	Do. do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	108 —111	108 —111	...	...
1,294,100*l*	Do. do. 4 p. c. Mortgage Debenture Stock	Stock	114 —117	114 —117	116⅜	114
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	15⅝— 15⅞	15⅝— 15⅞	15⅞	15⅝
62,700*l*	Do. do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	101 —104 xd	101 —104 xd	...	...
222,800*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	101 —104 xd	101 —104 xd	101½	...
320,000*l*	Do. do. 4 p. c. Debenture Stock	Stock	114 —117	115 —118	116⅜	116
108,700*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	101 —104 xd	101 —104 xd	...	...
146,800*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	101 —104 xd	101 —104 xd	...	...
300,000*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	103 —106	103 —106	...	...
200,000*l*	Do. 4 p. c. Reg. Mt. Debs. (Mauritius Subsidy) 1 to 8,000	25	106 —109 %	106 —109 %	107¼	...
120,000	Electric Construction, Limited, Nos. 1 to 120,000	£2	½— 1	½ — 1	...	...
12,845	Do. do. 7 p. c. Cum. Pref., Nos. 1 to 12,845	2	¾— 1¼	1 — 1½	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ...	... ...	...	...
100,000	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	... ...	... ...	...	...
91,195	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	⅛— ⅜	⅛— ⅜	...	...
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	0 — ¼	0 — ¼	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	½— 1½	½— 1½	...	...
180,227	Globe Telegraph and Trust, Limited	10	8⅝— 8⅞	8½— 8¾	8 13/16	8⅝
180,042	Do. do. 6 p. c. Preference	10	15½— 15⅝	15⅝— 15⅝	15 9/16	15½
150,000	Great Northern Tel. Company of Copenhagen	10	20 — 20¼xd	19¾ - 20¼ xd	20⅛	20
200,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	104 —107	104 —107	...	...
12,134*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	4½— 5½	4½— 5½	...	...
9,600*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	6 — 7	6 — 7	...	...
50,000	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	21½— 22½	22 — 23	22⅝	22⅛
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	41 — 44	41 — 44	43	42½
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	1 — 2	1 — 2	...	...
30,000	†Liverpool Electric Supply, £3 10s. paid	5	4⅛— 4⅜	4⅛— 4⅜	...	...
15,000	Do. do. fully paid	5	6½ — 6⅞	6⅛— 6⅜	6½	...
37,500	Liverpool Overhead Railway Ordinary, fully paid	10	5 — 5¼	4⅞— 5⅛	5	...
6,295	Do. do. Pref., £6 paid	10	6⅛ — 6¼	8⅛— 8¼	...	...
37,548	London Platino-Brazilian Telegraph, Limited	10	4 — 6	4 — 6	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	105 —108	105 —108	105	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£10 paid)	10	7⅞— 8¼	8 — 8½	8¼	7 15/16
50,000*l*	Do. 5 p.c. debentures, 1 to 5,000 in bonds of £10, £20, £40	...	103 —106	104 —108	105½	...
15,000	Monte Video Telephone Co., Ord., Nos. 1 to 15,000 fully paid ...	5	½— 1½	½— 1½	...	...
28,000	Do. do. 6 p. c. Pref., Nos. 1 to 28,000 fully paid	5	2 — 3	2 — 3	...	...
484,597	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜ — 4⅞	4⅜ — 4⅞	4⅞	4 11/16
15,000	Do. 6 p. c. Cum., 1st Preference	10	13½ — 14½	14 — 15	14¾	...
15,000	Do. 6. p. c. Cum. 2nd Preference	10	13½ — 14½	13½ — 14½	14½	...
119,234	Do. 5 p. c. Non-cum. 3rd Pref., Nos. 1 to 90,950 ...	5	5⅛ — 5⅜	5¼— 5½	5⅜	5 5/16
726,477*l*	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	111 —113 xd	112 —114 xd	113	112½
48,800	New Telephone, Limited, Nos. 25,901 to 74,700 ... (£2 paid)	10	... ...	... ...	...	...
6,452	Notting Hill Electric Lighting Company, Limited, fully paid ...	10	4½ - 5½	4½— 5½	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	¼— ⅜	¼— ⅜	...	...
100,000*l*	Pacific and European Tel., Ltd., 4 p. c. Guar. Debs., Nos. 1 to 1,000	100	100 —103 xd	100 —103 xd	...	...
11,802	Reuter's Limited	8	5½ - 6½	5½— 6½	...	...
19,980	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	5½— 6	5¾— 6¼	6½	5⅞
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	7⅜ - 8¼	8 — 8⅜	8 7/16	8¼
3,381	Submarine Cables Trust	Cert.	114 —119	114 —119	115	114½
78,942	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	2¼— 2⅜xd	2¼ - 2⅜ xd	2⅜	...
37,350	Telegraph Construction and Maintenance, Limited	12	36 — 38	36 — 38	37½	36
150,000*l*	Do do. do. 5 p. c. Bonds, red. 1894	100	103 —106 xd	103 —106 xd	...	...
58,000	United River Plate Telephone, Limited	5	2 — 2½	1⅞— 2	1½	...
146,370*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	90 —100 xd	90 —100 xd	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	5½— 6½	5½— 6½	...	...
260,900*l*	Do. do. do. 5 p. c. Debentures	100	99 —102	99 —102	...	...
30,000	West Coast of America Telegraph, Limited	10	2 — 3	1½ - 2½	2	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	97 —101 xd	97 —101 xd	...	...
64,242	Western and Brazilian Telegraph, Limited	15	6 — 6½	6 — 6½	6½	6 7/16
33,129	Do. do. do. 5 p. c. Cum. Preferred	7½	5½ - 5⅝	5½— 5⅝	5⅝	5½
33,129	Do. do. do. 5 p. c. Deferred	7½	1⅜ - 1⅝	1⅜ — 1½	...	...
178,100*l*	Do. do. 6 p. c. Debentures "A," 1910 ...	100	104 —107	104 —107	...	...
222,700*l*	Do. 5 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	104 —107	104 —107	...	..
88,321	West India and Panama Telegraph, Limited	10	1 — 1¼	1 — 1¼	...	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	9⅜— 10¼	9⅜— 10¼	...	...
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	8½— 9½	8½ - 9½	...	...
80,000*l*	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	105 —108 xd	105 —108 xd	...	...
$1,214,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	113 —118	113 —118	...	...
169,000*l*	Do. do. 6 p. c. Sterling Bonds	100	102 —105	102 —105	...	...
49,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	5 — 5½	5 — 5½	5½	5 3/16

‡ Unless otherwise stated all shares are fully paid.

† Quotations on Liverpool Stock Exchange.

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Birmingham Electric Supply Company, Ordinary of £5 (fully paid) 5¼– 6¼.—Brush Company, 4½ per cent. Debenture Stock, issued at 1 per cent. premium, 106—108.—Electric Construction Corporation 6 per cent. Debentures 87– 92.—Electric and General Investment, shares of £5 (£1 paid), 1¼—2¼.—Founders' shares, 200—225.—Electricity Supply Corporation, Ordinary of £5, 5– 5¼.—House to House Company (£5 paid) 1—1¼.—Do. 7 per cent. Preference of £5, 5¼—5¾.—Do. 6 per cent. Debentures of £100, 101—103.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 4¾—6¼, 1st Preference Cumulative 6 per cent., £5 (fully paid), 1¼– 6¾.—Liverpool Electric Supply, £5 (fully paid) 6¼—4¾.—Do. £3 10s. paid, 4¼—4¾.—London Electric Supply Corporation. £5 Ordinary, 7—1¼.—Manchester Edison and Swan Company £5 (£1 paid), 6—6¼.—Queen Anne's Mansions Lighting and Heating 6 per cent £100 Debentures, 101—103.—Yorkshire House-to House Electricity Company, £5 Ordinary Shares (£4 10s. paid) 4¼—4¾.

Bank rate of discount, 3 per cent. (October 5th, 1893.)

A DYNAMICAL THEORY OF THE ELECTRIC AND LUMINIFEROUS MEDIUM.*

By JOSEPH LARMOR, F.R.S., Fellow of St. John's College, Cambridge.

(*Continued from page* 23.)

We shall plunge into the subject at once from the optical side, if we assume that dielectric polarisation consists in a strain in the æther, of the rotational character contemplated above. The conditions of internal equilibrium of a medium so strained are easily worked out from MacCullagh's expression for w, its potential energy. If the vector (f, g, h) denote the curl or vorticity of the actual linear displacement of the medium, or *twice* the absolute rotation of the portion of the medium at the point considered, and the medium is supposed of crystalline quality and referred to its principal axes, so that

$$w = \tfrac{1}{2} \int (a^2 f^2 + b^2 g^2 + c^2 h^2)\, d\tau,$$

where $d\tau$ is an element of volume, it follows easily that for internal equilibrium we must have

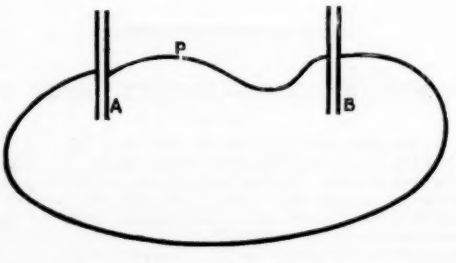
$$a^2 f\, dx + b^2 g\, dy + c^2 h\, dz = -\, dv,$$

a complete differential, and that over any boundary enclosing a region devoid of elasticity the value of v must be constant. Such a boundary is the surface of a conductor; v is the electric potential in the field due to charges on the conductors; (f, g, h) is the electric displacement in the field, circuital by its very nature as a rotation, and $(a^2 f, b^2 g, c^2 h)$ is the electric force derived from the electric potential v. The charge on a conductor is the integral of (f, g, h) over any surface enclosing it, and cannot be altered except by opening up a channel devoid of elasticity, in the medium, between this conductor and some other one; in other words, electric discharge can take place only by rupture of the elastic quality of the æthereal medium.

[At the interface between two dielectric media, taken to be crystalline, as above, the condition comes out to be that the tangential electric force is continuous. When the circumstances are those of equilibrium, and, therefore, an electric potential may be introduced, this condition allows discontinuity in the value of the potential in crossing the interface, but demands that the amount of this discontinuity shall be the same all along the interface; these are precisely the circumstances of the observed phenomena of voltaic potential differences. The component, normal to the interface, of the electric displacement is of course always continuous, from the nature of that vector as a flux.

It may present itself as a difficulty in this theory that, as the electric displacement is the rotational displacement of the medium, its surface integral over any sheet should be equal to the line integral of the linear displacement of the medium round the edge of the sheet; therefore that for a closed sheet surrounding a conductor this integral should be null, which would involve the consequence that the electric charge on a conductor cannot be different from null. This line of argument, however, implies that the linear displacement is a perfectly continuous one, which is concomitant with and required by the electric displacement. The legitimate inference is that the electric displacement in the medium which corresponds to an actual charge cannot be set up without some kind of discontinuity or slip in the linear displacement of the medium; in other words, that a conductor cannot receive an electric charge without rupture of the surrounding medium; nor can it lose a charge once received without a similar rupture. The part of the linear displacement that remains, after this slip or rupture has been deducted from it, is of elastic origin, and must satisfy the equations of equilibrium of the medium. —*December 7th*, 1893.]

We can produce in imagination a steady electric current, without introducing the complication of galvanic batteries, in the following manner, and thus examine in detail all that is involved, on the present theory, in the notion of a current. Suppose we have two charged condensers, with one pair of coatings connected by a narrow conducting channel, and the other pair connected by another such channel, as in the annexed diagram, where the dark regions are dielectric and



the white regions conducting. If we steadily move towards each other the two plates of the condenser, A, a current will flow round the circuit, in the form of a conduction current in the conductors and a displacement current across the dielectric plates of the condensers. Let us suppose the thicknesses of these dielectric plates to be excessively small, so as to minimise the importance of the displacement part of the current. There is then practically no electric force, and therefore no electric displacement, in the surrounding dielectric field, except between the plates of the condensers and close to the conducting wires. Consider a closed surface passing between the faces of the condenser, A, and intersecting the wire at a place, P. A movement of the faces of this condenser alters the electric force between them, and therefore alters the electric displacement across the portion of this closed surface which lies in that part of the field; as we have seen there is practically no displacement, anywhere else in the field except at the conducting wire; therefore to preserve the law of the circuital character of displacement throughout the whole space, we must suppose that this alteration is compensated by a very intense change of displacement at the conducting wire. So long as the movement of the plates continues, as long does this flow of displacement along the wire go on; it constitutes the electric current in the wire. Now, in calculating the magnetic force in the field, which is the velocity of the æthereal medium, from the change of electric displacement, we must include in our integration the effect of this sheet of electric displacement flowing along the surface of the perfectly conducting wires, for exactly the same reason as in the correlative problem in hydrodynamics, of calculating the velocity of the fluid from the distribution of vorticity in it, Helmholtz had to consider a vortex sheet as existing over each surface across which the motion is discontinuous.

The next stage in this mode of elucidation of electrical phenomena, is to suppose, once the current is started in our non-dissipative circuit, that both the condensers are instantaneously removed, and replaced by continuity of the wire. We are now left with a current circulating round a complete perfectly conducting channel, which in the absence of viscous forces will flow round permanently. The expression for the kinetic energy in the field is easily transformed from a volume integral of the magnetic force, which is represented by the velocity of the medium $\frac{d}{dt}(\xi, \eta, \zeta)$, to an integral involving the current $\frac{d}{dt}(f, g, h)$, which is in the present case a line integral round the electric circuit. The result is Franz Neumann's celebrated formula for the electro-magnetic energy of a linear electric current,

$$T = \tfrac{1}{2}\, i^2 \iint r^{-1} \cos\epsilon\, ds\, ds;$$

or we may take the case of several linear circuits in the field, and obtain the formula

$$T = \tfrac{1}{2} \Sigma\, i^2 \iint r^{-1} \cos\epsilon\, ds\, ds + \Sigma\, i_1\, i_2 \iint r^{-1} \cos\epsilon\, ds_1\, ds_2,$$

which is sufficiently general to cover the whole ground of electrodynamics.

Our result is in fact that a linear current is a vortex ring in the fluid æther, that electric current is represented by vorticity in the medium, and magnetic force by the velocity of the medium. The current being carried by a perfect conductor, the corresponding vortex is (as yet) without a core, *i.e.*, it circulates round a vacuous space. [The strength of a vortex ring is, however, permanently constant; therefore, owing to the mechanical connections and continuity of the medium, a current flowing round a complete perfectly conducting circuit would be unaffected in value by electric forces induced in the circuit, and would remain constant throughout all time. Ordinary electric currents must therefore be held to flow in incomplete conducting circuits, and to be completed either by convection across an electrolyte, or by electric displacement or discharge across the intervals between the molecules, after the manner of the illustration given. —*December 7th*, 1893]

Now we are here driven upon Ampère's theory of magnetism. Each vortex-atom in the medium is a permanent non-dissipative electric current of this kind, and we are in a position to appreciate the importance which Faraday attached to his discovery that all matter is magnetic. Indeed, on consideration, no other view than this seems tenable; for we can hardly suppose that so prominent a quality of iron as its magnetism completely disappears above the temperature of recalescence, to reappear again immediately the iron comes below that temperature; much the more reasonable view is that the molecular rearrangement that takes place at that temperature simply masks the permanent magnetic quality. In all substances other than the magnetic metals, the vortex atoms pair into molecules and molecular aggregates in such way as to a large extent cancel each other's magnetic fields; why in iron at ordinary temperatures the molecular aggregates form so striking an exception to the general rule is, for some reason, peculiar to the substance, which, considering the complex character of molecular aggregation in solids, need no excite surprise.

We have now to consider the cause of the pairing together of atoms into molecules. It cannot be on account of the magnetic, *i.e.*, hydrodynamical, forces they exert on one another, for two electric currents would then come together so as always to reinforce each others' magnetic action, and all substances would be strongly magnetic. The ionic electric charge, which the phenomena of electrolysis show to exist on the atom, supplies the attracting agency. Furthermore, the law of attraction between these charges is that of the inverse square of the distance, and between the atomic currents is that of the inverse cube; so that, as in the equilibrium state of the molecule these forces are of the same order of intensity and counteract each other, the first force must have much the longer range, and the energy of chemical combination must therefore be very largely electrostatic, due to the attractiou of the ions, as von Helmholtz has clearly made out from the phenomena of electrolysis and electrolytic polarisation.

But in this discussion of the phenomena of chemical combination of atoms we have been anticipating somewhat. All our conclusions, hitherto, relate to the æther, and are therefore about electromotive forces. We have not yet made out why two sets of molecular aggregates, such as constitute material bodies, should attract or repel each other when they are charged, or when electric currents circulate in

* Abstract of paper read before the Royal Society. (Received November 15th, 1893.)

them; we have, in other words, now to explain the electro-static and electro-dynamic forces which act between material systems.

Consider two charged conductors in the field; for simplicity, let their conducting quality be perfect as regards the very slow displacements of them which are contemplated in this argument. The charges will then always reside on their surfaces, and the state of the electric field will, at each instant, be one of equilibrium. The magnitude of the charge on either conductor cannot alter by any action short of a rupture in the elastic quality in the æther; but the result of movement of the conductors is to cause a rearrangement of the charge on each conductor, and of the electric displacement (f, g, h) in the field. Now, the electric energy, W, of the system is altered by the movement of the conductors, and no viscous forces are in action; therefore the energy that is lost to the electric field must have been somehow spent in doing mechanical work on the conductors; the loss of potential energy of the electric field reappears as a gain of potential energy of the conductors. We have to consider how this transformation is brought about. The movement of the conductors involves, while it lasts, a very intense ideal flow of electric displacement along their surfaces, and also a real change of displacement of ordinary intensity throughout the dielectric. The intense surface flow is in close proximity with the electric flows round the vortex atoms which lie at the surface; their interaction produces a very intense elastic disturbance in the medium, close at the surface of the conductor, which is distributed by radiation through the dielectric as fast as it is produced; the elastic condition of the dielectric, on account of its extreme rapidity of propagation of disturbances compared with its finite extent, being always extremely nearly one of equilibrium. It is, I believe, the reaction on the conductor of these wavelets which are continually shooting out from its surface, carrying energy into the dielectric, that constitutes the mechanical forcive acting on it. But we can go further than this; the locality of this transformation of energy, so far at any rate as regards the material forcive, is the surface of the conductor; and the gain of mechanical energy by the conductor is, therefore, correctly located as an absorption of energy at its surface; therefore, the forcive acting on the conductor is correctly determined as a surface traction, and not a bodily forcive throughout its volume. One mode of representing the distribution of this surface traction, which, as we know, gives the correct amount of work for every possible kind of virtual displacement of the surface, is to consider it in the ordinary electrostatic manner as a normal traction due to the action of the electric force on the electric density at the surface; we conclude that this distribution of traction is the actual one. To recapitulate: if the dielectric did not transmit disturbance so rapidly, the result of the commotion at the surface produced by the motion of the conductor would be to continually start wavelets which would travel into the dielectric, carrying energy with them. But the very great velocity of propagation effectually prevents the elastic quality of the medium from getting hold; no sensible wave is produced, and no flow of energy occurs into the dielectric. The distribution of pressure in the medium which would be the accompaniment of the wave motion still persists, though it now does no work in the dielectric; it is this pressure of the medium against the conductor that is the cause of the mechanical forcive.

The matter is precisely illustrated by the fundamental *aperçu* of Sir George Stokes with regard to the communication of vibrations to the air or other gas. The rapid vibrations of a tuning-fork are communicated as sound waves, but much less completely to a mobile medium like hydrogen than to air. The slow vibrations of a pendulum are not communicated as sound waves at all; the vibrating body cannot get a hold on the elasticity of the medium, which retreats before it, preserving the equilibrium condition appropriate to the configuration at the instant; there is a pressure between them, but this is instantaneously equalised throughout the medium as it is produced, without leading to any flow of vibrational energy.

Now, let us formally consider the dynamical system consisting of the dielectric media alone, and having a boundary just inside the surface of each conductor; and let us contemplate motions of the conductors so slow that the medium is always indefinitely near the state of internal equilibrium or steady motion, that is conditioned at each instant by the position and motion of the boundaries. The kinetic energy, T, of the medium is the electro-dynamic energy of the currents, as given by Neumann's formula; and the potential energy, W, is the energy of the electrostatic distribution corresponding to the conformation at the instant; in addition to these energies we shall have to take into account surface tractions exerted by the enclosed conductors on the medium, at its boundaries aforesaid. The form of the general dynamical variational equation that is suitable to this problem is

$$\delta \int (T - W)\, dt + \int dt \int \delta w\, ds = 0,$$

where $\delta w\, ds$ represents the work done by the tractions acting on the element, ds, of the boundary, in the virtual displacement contemplated. If there are electromotive sources in certain circuits of the system, which are considered to introduce energy into it from outside itself, the right-hand side of this equation must also contain an expression for the work done by them in the virtual displacement contemplated of the electric co-ordinates. Now, this variational equation can be expressed in terms of any generalised co-ordinates whatever, that are sufficient to determine the configuration in accordance with what we know of its properties. If we suppose such a mode of expression adopted, then, on conducting the variation in the usual manner and equating the co-efficients of each arbitrary variation of a co-ordinate, we obtain the formulæ

$$\Phi = \frac{d}{dt}\frac{dT}{d\phi} - \frac{dT}{d\phi} + \frac{dw}{d\phi},$$

$$E = \frac{d}{dt}\frac{dT}{de}$$

In these equations Φ is a component of the mechanical forcive exerted on our dielectric system by the conductors, as specified by the rule that the work done by it in a displacement of the system represented by $\delta\phi$, a variation of a single co-ordinate, is $\Phi\,\delta\phi$: the corresponding component of the forcive exerted by the dielectric system on the conductor is of course $-\Phi$. Also E is the electromotive force which acts from outside the system in a circuit in which the electric displacement is e, so that the current in it is $\dot{e}$; the electromotive force induced in this circuit by the dielectric system is $-E$.

These equations involve the whole of the phenomena of ordinary electro-dynamic actions, whether ponderomotive or electromotive, whether the conductors are fixed or in motion through the medium: in fact, in the latter respect no distinction appears between the cases. They will be completed presently by taking account of the dissipation which occurs in ordinary conductors.

These equations also involve the expressions for the electrostatic ponderomotive forces, the genesis of which we have already attempted to trace in detail. The generalised component, corresponding to the co-ordinate ϕ, of the electrostatic traction of the conductors on the dielectric system, is $d\,W/d\,\phi$; therefore the component of the traction, somehow produced, of the dielectric system on the conductors is $-\,d\,W/d\,\phi$.

The stress *in the æther* between two electrified bodies consists of a tangential traction on each element of area, equal in magnitude to the tangential component of the electric force at that place, and at right angles to its direction. The stress in the *material* of the dielectric is such as is produced in the ordinary manner by the surface tractions exerted on the material by the conductors that are imbedded in it. The stress in the dielectric of Faraday and Maxwell has no real existence; it is in fact such a stress as would be felt by the surface of a conductor used to explore the field, when the conductor is so formed and placed as not to disturb the electric force in the dielectric. The magnetic stress of Maxwell is simply a mathematical mode of expression of the kinetic reaction of the medium.

The transfer of a charged body across the field with velocity not large compared with the velocity of electric propagation carries with it the whole system of electric displacement belonging to the body, and therefore produces while it lasts a system of displacement currents in the medium, of which the circuits are completed by the actual flow of charge along the lines of motion of the different charged elements of the body.

The phenomena of the electrostatic polarisation of dielectrics were at one time provisionally represented by Faraday as due to the orientation of electric polar elements of the medium by the electric force, just as magnetisation is actually due to the orientation of the magnetic polar elements by the magnetic force of the field; and this theory was developed at length by Mossotti. At a later period Maxwell himself ("Dynamical Theory," section 11) compared the electric displacement in a dielectric medium to an actual displacement of the electric charge on conducting molecules imbedded in it—a conception mathematically equivalent to the above. In a previous paper * I have explained by simple reasoning that this view is inconsistent with the circuital character of the electric current, a conclusion in agreement with that of von Helmholtz, who adopted this idea in his generalised theory of electro-dynamics. It is therefore necessary to obtain a complete view of this matter from our present standpoint. The polarised molecule, with its positive and negative ions, is as we have seen a reality; but if the current is to remain circuital, the action of the electric force of the field must not affect the actions between the constituent vortices which are the cause of their orientation, nor the distribution of the electric charges on the atoms, so much as to produce any sensible electric displacement of this kind. These restrictions might be secured by taking the two poles of the molecule sufficiently close together, and by taking the dimensions of the conducting atom sufficiently small.

As regards the second of these hypotheses, it is to be observed that the moment of electric induction in a conducting atom depends only on its size, and not on the intensity of its free electrification; for the case of conducting spherules the electric moment produced by the action of an electric force, F, is $3\,F/4\,\pi$ multiplied by the total volume of the atoms, and this would give a dielectric inductive coefficient equal to three times the ratio of the aggregate volume of the atoms to the whole volume of the region, a result which is, in any case, far too small to represent the facts, and may easily be so small as to be quite negligible, so as to leave the current practically circuital.

(*To be continued.*)

THE NOVAK INCANDESCENT LAMP CASE.

Another incandescent lamp case is now being tried in America, despite the fact that the Edison patent has scarcely more than a year to run in that country. The leading point at issue in the present case lies in the circumstance that in the Novak lamp the filament is surrounded by a moderately rarefied atmosphere consisting largely of bromine vapour; the required degree of exhaustion being obtained by mechanical pumps producing, it is claimed, a rarefaction of only about $\frac{1}{50}$th of an atmosphere. As is well known, the degree of exhaustion reached and considered necessary in the ordinary incandescent lamp is very much higher than this; the lowest practicable limit, in Mr. Howell's opinion (one of the Edison Company's witnesses), being about $\frac{1}{1000}$th of an atmosphere.

The case was brought by the Edison Electric Light Company against the Waring Electric Company in the U.S. Circuit Court, before Judge Shipman; the counsel representing either side

* "On the Theory of Electro-dynamics," *Proc. Roy. Soc.*, 1891, p. 522.

being almost identically the same as those who have appeared in the numerous lamp suits which have lately been heard. Many points of considerable scientific interest, in addition to the legal claim of non-infringement which was urged by the defendant company, were brought up, and it is these scientific points which will constitute the principal theme of interest to our readers.

The principal arguments advanced by the complainant company are as follows:—It is maintained that in all material respects the Novak lamp is made under Edison's master patent, since it embodies a carbon filament, an all-glass receiver, conducting wires passing through the glass, and a practical vacuum. The degree of vacuum necessary has not been defined in the Courts, all that has been held being that it must be "sufficient." For various reasons, it is desirable to have a high degree of vacuum, but the lamp is serviceable and commercial within wide limits. Residual gases in any appreciable quantity in the bulbs are objectionable, because more heat is lost by conduction, because thinner filaments are necessary to give a given amount of light with a given amount of electric energy, because the bulbs get hot and cause injury to the fittings, and so forth; and it is claimed that although the lamp may still be serviceable, it is worse instead of better (as is claimed by the defendants) than Edison's. It is claimed that the Novak does not blacken, and that the candle-power is maintained much longer than those of the Edison company's manufacture; and it is the discussion on this branch of the case that forms so interesting a feature in the case. The view put forward to account for the blackening of lamps in the affidavits presented by the Waring Company is that carbon vapourises more rapidly at a given temperature in high than in low vacua, and that as a consequence the filament in the Edison lamps wastes away more rapidly than in the Novak lamp. Counsel for the Edison Company, however, characterised this view as ingenious, but absurd, because carbon cannot vapourise except at a very high temperature, say, something like 40,000° F.; and, further, it has been shown by the most careful investigation that this phenomenon of blackening does not reduce the size of the filament or make it liable to break. Further on we reproduce a most interesting affidavit by Edison himself, in which his views on this subject are explained at considerable length.

The complainants also maintain that in some of the Novak lamps, the 32 C.P. and 50 C.P. to wit, the vacua are sufficiently high to withstand the Edison factory test. In two specific instances they were estimated at $\frac{1}{30000}$th and $\frac{1}{10000}$th of an atmosphere. It was also pointed out that the Waring Company is nothing more than the Perkins Electric Lamp Company—a concern which has already been enjoined to discontinue lamp manufacture—since the officers, factory, stockholders, &c., are the same in the new company as in the old. The defendants make a great claim of novelty in introducing a gas into the lamp bulbs, but, as a matter of fact, Edison himself had long ago worked on this line, and had taken out patent No. 274,295, granted March 20th, 1883, embodying the procedure. With regard to the comparison tests which had been made and put in evidence by the defendant company, counsel declared that they had been unfairly and improperly carried out, the Novak lamps having been run at much lower incandescence than the Edison; besides which old Edison lamps, containing untreated filaments, had been selected for trial instead of the new kind of lamps containing treated filaments, which are now being made. The Novak lamp was simply a subterfuge, and even admitting the claims in its favour, it would be merely an improvement on the Edison lamp. As it is, they have only to decide how much gas they can introduce and still obtain a successful lamp. Perhaps the clearest way to look at the question is to suppose the case reversed, and that the Waring patent had been issued first. Would anyone for a moment presume to say that the Edison patent embodying a higher degree of vacuum did not infringe? The object of the patent law is to secure to the first inventors a monopoly of what they have actually invented or discovered, and it ought not to be defeated by a too strict and technical adherence to the letter.

The defendants, on the other hand, based their claims to non-infringement on the broad fact that their lamps were exhausted by means of mechanical pumps, which were incapable of exhausting beyond $\frac{1}{1000}$th of an atmosphere, that no pains were taken to remove the occluded gases from the filaments during exhaustion, that the exhausting operation was completed in about 9 or 10 minutes, instead of 2 or 3 hours by the customary process, and that air was expelled by the novel means of substituting bromine vapour, which is inert towards carbon. This proceeding is entirely different from that patented by Edison, and it is further claimed that by its means the lamps are more economically made, and are better than vacuum lamps by reason of their non-blackening property. The exhausting operation is carried on by women; the pumps are worked for two to three minutes, then bromine vapour is admitted, and the operation is performed three times in succession, the lamps being removed after the third exhaust. The defendants argue that since Edison's patent is only for the entire combination, and that since their vacuum cannot be called a "nearly perfect vacuum," they do not infringe that patent. It has over and over again been asserted that one of the main reasons why the incandescent lamp did not prove a success in the hands of workers prior to Edison, was on account of the crude means at their disposal for obtaining a sufficiently perfect vacuum, and it is claimed that the defendants' bromine atmosphere is a substantially new and practical invention.

The connection between the Perkins Company and the Waring Company is explained by the circumstance that John Waring was in the employ of the former concern, and that he conceived and patented the invention, and that it, and the right to use it, belonged to him alone, and not to the Perkins Company; and further, that without the knowledge of the other officers of the Perkins Company, he proceeded, on January 18th, 1893, to organise a corporation for the purpose of owning and operating his invention, and that it was only after many negotiations that the present stockholders purchased the new undertaking. In an affidavit made by Mr. Waring, electrician to the defendant company, it is admitted that more electrical energy was required to bring a lamp made according to his invention to its candle-power, than if it had a vacuum such as Edison described. The difference in amount was from 6 to 8 per cent. But by using a smaller filament with the same electric energy, an equal amount of light is obtained, the light being, he declared, of better quality. In an affidavit of Prof. Anthony, it is asserted that the introduction of bromine was not used for the wrongful evasion of the Edison patent only, but also for substantial and important advantages that resulted, the principal being: "(*a*) A great saving in ease and cheapness of manufacture; (*b*) a radical lengthening of the life of the lamp at its initial efficiency; (*c*) an avoidance of the vapourisation of the carbon and its deposit on the inside of the glass chamber, avoiding blackening and discolouration of the glass, and the obscuration of the light."

The decision of the case is anxiously awaited in America. We append the affidavit of Thomas A. Edison:—

"I am the Thomas A. Edison upon whose patent for improvement in electric lamps this suit is brought.

"I have read the affidavits of John Waring and William A. Anthony, given for the defendants in this case.

"I understand the construction of the 'Novak' incandescent electric lamp made by the defendants, as well as the methods and processes employed in its manufacture, so far as such processes are disclosed.

"The 'Novak' lamp is, in all its essential features, a copy of the lamp described in my patent. It is a vacuum lamp having the carbon filament, platinum wires, and entire glass receptacle of my lamp, and a sufficient vacuum to prevent, to a practical extent, the disintegration of the carbon filament. This lamp, however, instead of employing a high vacuum for the preservation of the carbon filament, uses what has been for a number of years known to be the equivalent of such a vacuum, and that it is a highly rarefied atmosphere composed of a gas which does not combine chemically with carbon at high temperatures. Practically, all oxygen is, however, eliminated from the lamp chamber, and, indeed, so far as oxygen and atmospheric air are concerned, the lamp is provided with a high vacuum, and the small quantity of inert gas which is employed is not sufficient to produce marked injurious effects or to render the lamp uncommercial.

"It is stated in the defendants' affidavits, which I have read, that no attempt is made to drive the occluded gases out of the carbon filament of the 'Novak' lamp during the pumping operation. This, however, is not necessary, since the carbon filament employed is one which has been previously subjected to the process of hydro-carbon treatment. By this process the carbon filaments are immersed in a hydro-carbon, and while so immersed are brought up to vivid incandescence by means of the electric current. The result is to decompose the hydro-carbon and deposit a coating of carbon upon the filaments. At the same time the filament is consolidated, and the occluded gases are driven out of it.

"With filaments so treated, it has been known for a number of years that the heating of the filaments during the exhausting process was not required to drive the occluded gases out of the filaments themselves. This practice, however, has been continued in the ordinary manufacture of incandescent lamps, for the purpose, largely, of heating the walls of the glass receptacle so as to drive out, as far as possible, the film of air which adheres to the glass walls.

"In my patent, No. 264,650, granted September 19th, 1892, the lamp during the exhausting operation is inclosed by a metal case, so as to more effectively heat the glass walls by the heat of the filaments.

"In my patent, No. 411,018, granted September 17th, 1889, I propose to exhaust the lamps without heating the filaments, the glass chamber, however, being heated by external means.

"The invention goes back to the year 1880, and was originally set out in an application filed December, 1881, soon after the application upon which patent No. 264,650 was granted.

"I have made many practical and commercial incandescent electric lamps by the employment of the exhausting process described in patent No. 411,018, and it has been well understood by myself and others since the year 1880, that with a filament of carbon from which the occluded gases have been driven by the hydrocarbon treatment process, the high vacuum necessary for a commercial incandescent electric lamp can be secured without the heating of the filaments themselves during the exhausting process. Where the lamp globe is washed out by an inert gas, as is the case in the manufacture of the 'Novak' lamp, it is not necessary to even heat the glass receptacle, since the air adhering to the glass walls will be, to a large extent, washed out by the successive withdrawals of the inert gas.

"Notwithstanding what is said in the affidavits of Mr. Waring and Prof. Anthony, I know, from my own experience, that the employment of even a small quantity of inert gas in an electric lamp is not an advantage, and that the bromine vapour is not exceptional in this respect.

"This entire subject was thoroughly investigated by me in 1882, and the result of that investigation is set forth in my patent, No. 274,295, granted March 20th, 1883.

"In that patent there is described the employment of an inert gas at a definite degree of exhaustion, for the purpose of preventing the disintegration of the carbon filament, and the deposit of carbon upon the glass globe.

"The special gases described are nitrogen and hydrochloric acid, but I employed in my experiments many other gases, including chlorine and bromine. I preferred other gases than chlorine and bromine, because I was using mercury pumps in my manufacture, and these gases actively attack mercury, and great care has to be taken to prevent that action.

"It will be observed that in that patent I describe the heating of the carbon filament during the process of exhaustion, but state that such heating may be omitted. I had in mind, in making the last statement, that with carbon filaments treated by the hydro-carbon

treatment process, or otherwise made so as to be free from occluded gases, the heating of the filaments during the exhausting process would not be essential to the making of a successful lamp. In that patent it will be seen that with hydrochloric acid gas the effects which I desired to produce could be attained with a less pressure than with a lighter gas, such as nitrogen, and the patent provides a means for determining the pressure with each gas.

"The theory of the action of such a rarefied gas in an incandescent electric lamp, and the philosophy underlying the disintegration of the carbon filaments in vacuum lamps are somewhat obscure, and are evidently entirely misunderstood by Prof. Anthony.

"Prof. Anthony assumes that the disintegration is due to vapourisation of the carbon at high temperature, producing a vapour of pure carbon, which floats in the vacuous space and deposits on the glass walls of the inclosing chamber. On this assumption he suggests that the temperature of vapourisation of the carbon is lower as the pressure of the surrounding atmosphere is lower, and, consequently, that the pressure of an inert gas exerting an increased pressure raises the vapourising point and enables the same or a higher temperature to be employed without vapourisation of the carbon. This result, he thinks, is attained in the 'Novak' lamp, and is proved to his satisfaction by a less blackening of the globe in those lamps.

"The disintegration of the carbon filament is produced by other cause, and is not diminished in the slightest degree, but is rather increased by the presence of a gas pressure.

"It is true that the presence of a rarefied gas reduces the blackening of the globe, but this is due to the Geissler tube phenomena, which are set out in my patent No. 274,295. The disintegration is present when the gas is employed, but the carbon particles may not reach the glass globe. Whether they do reach the globe or not, is dependent upon whether the walls of the globe are sufficiently distant from the carbon filament to be outside of the sphere of action, as described in my patent.

"At the time of taking out my patent, No. 274,295, I believed that the disintegration of the carbon was actually reduced by the pressure of the gas, but this was an error arising from the absence of deposit on the globe, and I only found out by later and more elaborate tests of the lamps, that the disintegration actually took place, and in a greater degree than before, although the carbon was not deposited on the globe. Prof. Anthony and Mr. Waring have evidently fallen into this same error.

"The theory upon which Prof. Anthony concludes that the disintegration is reduced in the 'Novak' lamp is entirely erroneous. He assumes that this disintegration takes place evenly over the entire length of the carbon filament, and serves to increase its resistance by diminution of its size. Since an increase of resistance produces a lowering of the candle-power of the lamp at the same voltage, he assumes that the maintaining of candle-power is an indication of a checking of the disintegration.

"As a matter of fact, there is no appreciable wearing away of carbon filaments in vacuum lamps. When oxygen is present this result is plainly seen, but with a vacuum lamp, with or without a small quantity of inert gas, this effect is not produced.

"The increase in resistance which is observed, and which is the main cause of the reduction of candle-power, comes from some structural change in the carbon itself. I have often made most careful measurements of carbon filaments taken from lamps which have burned for long periods, and have dropped considerably in candle-power, and have never been able to detect any diminution in size.

"The breaking of the carbon filaments in modern lamps is not due to the gradual wearing away of the carbon, producing a weak point which finally breaks, but is caused by a crack at some point in the carbon filament, which appears without warning. This crack does not appear at any particular point in the carbon filament, nor, with the exception of defective carbons, can it be seen in advance of the formation of the crack where the break will occur.

"The rising or falling in candle-power of the lamp during use is no evidence of the amount of disintegration of the carbon. Such effects are dependent upon details of manufacture, and the lamps of each manufacturer have some peculiarities in that respect. The end sought is to maintain a high average candle-power throughout a reasonable life of the lamp. I see no reason why the 'Novak' lamp should differ in this respect from other lamps, and I am informed and believe that tests show that it does not differ substantially from the lamps of other makers in these characteristics.

"The use of bromine vapour in the 'Novak' lamps I believe to be a distinct disadvantage. The lessening of the blackening of the globe is of minor importance compared with other conditions. The presence of the gas makes it necessary to use a thinner, and hence less durable filament, and to operate it at a higher temperature, in order to secure the same amount of light for the same expenditure of energy. This fact, together with the increased disintegration incidental to the presence of the gas, must shorten, to some extent, this life of the lamp. I am informed, and believe that the 'Novak' lamps compare unfavourably with some other vacuum lamps in this respect.

"The ease and cheapness of manufacture supposed to result from the method employed for exhausting the 'Novak' lamp is, in my opinion, unimportant, if it exists at all.

"Referring to the alleged advantages set out at the end of Prof. Anthony's affidavit, I wish to say that, in my opinion, the first advantage, namely, a saving in ease and cheapness of manufacture, does not exist; that the second advantage, namely, a radical lengthening of the life of the lamp at its initial efficiency, does not exist; and that, as to the third advantages, namely, an avoidance of the vapourisation of the carbon and its deposit on the glass chamber—this supposed advantage is based upon an erroneous theory of the causes of the disintegration of carbon, and such disintegration takes place the same, or to a greater extent, in the 'Novak' lamp, than in lamps made in the ordinary way.

"It is true that the presence of the gas lessens the blackening and discolouration of the globe, and this is the only possible advantage it can have; but that advantage is more than offset by the disadvantages incidental to the use of such a gas.

"I observe that Prof. Anthony makes some comparisons between Edison lamps and Perkins and Novak lamps, with regard to maintaining of candle-power, which are unfavourable to the Edison lamp. In this connection I wish to state that, due to the respect which the Edison Company paid to the Weston patent covering the hydro-carbon treatment process, the process was not employed until recently in the regular manufacture of the Edison lamp. It has, however, been employed recently, owing to the upsetting of the Weston patent by the courts. I am informed that the decision declaring the Weston patent invalid is to be found in 51 Federal Reports, 24.

"Lamps provided with carbon filaments treated by the hydro-carbon process are undoubtedly superior, with respect to the maintaining of their candle-power, to lamps provided with filaments not so treated. Prof. Anthony undoubtedly made his comparison between Edison lamps with untreated filaments, and Perkins and Novak lamps with treated filaments.

"Lamp manufacturers who have infringed my patents have not hesitated to infringe the detail patents of others, and they have all employed the hydro-carbon treatment process, notwithstanding the existence of the presumably valid Weston patent, and the Edison Company, by reason of its respect of the rights of others, has been at considerable disadvantage, which infringing manufacturers, who have respected nobody's patents, have not been subjected to.

"Another reason for the unfavourable result of Prof. Anthony's comparisons is undoubtedly due to the fact that he compared Edison lamps and Perkins and Novak lamps operating at different degrees of efficiency.

"The Edison lamp made for central station use has an initial efficiency of about 3 watts per candle, while the Perkins and Novak lamps have an initial efficiency of about 4 watts per candle. This means that the Edison lamp referred to operates at a much higher degree of incandescence than the Perkins and Novak lamps, and hence should be expected to have a lower average candle-power.

"It is well understood that a proper comparison of lamps can be made only between lamps operated at the same efficiency, and Prof. Anthony has evidently overlooked this fact."

THE JUNIOR ENGINEERING SOCIETY.

AT a numerously attended meeting of this Society, held at the Westminster Palace Hotel, on Friday evening, 5th inst., Mr. Percy J. Waldram in the chair, an interesting lecture on "Boiler Incrustations and Deposits," was delivered by Prof. Vivian B. Lewes, F.I.C., F.C.S., Honorary Member.

The lecturer having pointed out the serious injury occasioned to boilers, and the waste of fuel due to the formation of incrustations, traced the history of various sources of water supply, and showed how the water acquired the power of forming deposits in steam generators. These deposits consist mainly of calcic carbonate, calcic sulphate, magnesic hydrate, and silica, the chemical processes which lead to their deposition in the feed-water differing in each case.

Calcic carbonate, which constitutes the principal ingredient in fresh water deposits, is thrown down in a dense form by the breaking up of soluble calcic bicarbonate under the influence of heat, and if it is nearly pure it forms a mud in the boiler, which can to a great extent be got rid of by blowing off.

Calcic sulphate, however, is deposited by an entirely different action, as its solubility decreases with rise of temperature, high pressure, or great increase in the saline properties of the solution; and its wonderful power of hardening deposits and binding them together into an incrustation, which can only be removed by the use of hammer and chisel, makes it a most dangerous constituent of such deposits. This hardening power is due to the fact that it deposits from water in the form of small angular crystals, and in this form gets mixed with the calcic carbonate mud. As these crystals become heated, they lose water of crystallisation, and change their form into fine needle-shaped crystals, which bind the mass together.

Magnesic hydrate, which is found in many scales, has always been supposed to be due to decomposition of magnesic chloride at a high temperature, but this is a mistake, the magnesic hydrate being produced by the interaction of magnesic chloride and calcic carbonate, which results in the formation of soluble calcic chloride, evolution of carbon dioxide and deposition of magnesic oxide, which, by combination with water, forms the hydrate.

Examples were given of scales from various waters, and it was shown that fresh water incrustations may be looked upon as consisting chiefly of impure calcic carbonate, whilst the deposit formed by the use of sea water is principally calcic sulphate. Brackish waters give incrustations consisting of nearly equal portions of these substances.

The question of oily deposits on plates was next considered, and the lecturer pointed out that, according to recent researches, mere wiping of a boiler plate with a greasy rag causes a serious diminution in its power of transmitting heat, whilst with an oily deposit $\frac{1}{16}$th of an inch in thickness, plates in some cases became so overheated as to be unable to withstand the pressure upon them, and collapse of the furnace crowns sometimes ensued.

The question of anti-incrustators was then dealt with, and the lecturer expressed his opinion that if manufacturers were obliged to use a hard water, the most reasonable method they could adopt was to soften it on a large scale before putting it into the boiler, as otherwise serious complications would arise in the boiler itself.

THE SOCIÉTÉ INTERNATIONALE DES ELECTRICIENS, PARIS.

The last meeting of the Société Internationale des Electriciens which took place on the 6th inst., at the usual place, is worthy of notice.

M. Claude spoke first on the means of increasing the safety of high-tension alternating current distributions, but he did not offer any considerations of great importance.

M. Hospitalier next addressed the meeting and gave a really interesting description of electrical industry in America. He summed up the general impression that he received from his visit to America. The economic conditions of that country are quite different from those of Europe. Labour is very dear; therefore, everything is as far as possible reduced to mechanism. M. Hospitalier then described the boilers which supply the steam to the exhibition. There were 52 boilers for feeding 82 motors of a total power of 25,000 H.P. The mean evaporation was 7,000 kilogrammes of water per hour and the heating was effected by means of petroleum. The dynamos are beginning to be worked direct without belts. The central stations consist of several floors on which we find in succession the dynamos, the steam motors, the boilers, the coal sheds, and the offices. In one station at New York there are eight dynamos of 800 kilowatts. The manufacture of accumulators has not made much progress. Lighting by arcs in series has greatly extended; there are now as many as 70 arcs in series. We can see what a number of machines would be required for a town using 3,000 arc lights. Two rival companies, the General and the Thomson-Houston effect distributions at 1,000 volts by means of alternating currents with frequencies of 60 periods per second. One point to be noted in all these works is that there is never any reserve power. The canalisations are wretched, the lines being nearly all overhead and fixed under bad conditions. Three meters are used—the Edison electrolytic meter, the Thomson-Houston watt-hour meter, and the Shallenberger ampère-hour meter. The applications of electric lighting are everywhere very numerous, being worked either by water or steam power. The transformers are generally of very low power; it is thought expedient to use a greater number which are distributed according to requirements. These apparatus are fixed to posts or supported against walls. The point most worthy of notice is the development of the use of electrical energy as motive power. Electric motors are used for working windlasses, lifts, ventilators, printing and other machines, pumps, &c. As an example of the transmission of electrical energy to a distance, the General Company had installed at the exhibition a steam engine working a continuous current dynamo of 220 volts. This latter supplied the electrical energy to a continuous current motor which worked a pump drawing water. This water was poured upon a Pelton wheel which started a triphased current alternator. The difference of potential was brought successively to 6,000, 3,000, and 110 volts by means of transformers. On this last voltage were working little triphased current motors. The Westinghouse dynamos must also be mentioned. In conclusion, M. Hospitalier noticed the various applications of electric traction at Boston, New York, Brooklyn, and St. Louis. He then criticised the overhead lines. He mentioned the experiments in electric welding for soldering the rails together. He also spoke of the decisions adopted by the Congress, noticed E. Gray's telautograph, a very complicated apparatus, and mentioned the very interesting experiments performed at the exhibition by Tesla.

NEW PATENTS—1893.

24,864. "Improved method and means of compounding dynamo-electric machines." E. Thomson. Dated December 27th. (*Complete.*)

24,865. "Improvements in insulators for electric wires." H. H. Lake. (Communicated by W. B. Rand, United States.) Dated December 27th. (*Complete.*)

24,867. "Improvements in electric railways." J. C. Love and A. G. Wheeler. Dated December 27th. (*Complete.*)

24,871. "Improvements in dry batteries." H. T. Johnson. Dated December 27th. (*Complete.*)

24,889. "Improvements in connection with phonographs, graphophones, and similar sound recording and reproducing machines." J. L. Young. Dated December 27th.

24,911. "Improvements in electric cables and in the method of making the same." T. J. Dewees. Dated December 27th. (*Complete.*)

24,926. "Improvements in the method of and means employed for completing electric circuits." W. Brierley. (Communicated by P. Weber and J. Heinrich, Germany.) Dated December 28th. (*Complete.*)

24,946. "Improvements in coverings for electric wires." F. S. Randall, E. Packard, J. Robinson, and W. J. Chaninel. Dated December 28th. (*Complete.*)

24,948. "A time electric switch." E. C. de Segundo and W. Derham. Dated December 28th. (*Complete.*)

24,951. "Improvements in electrical measuring instruments." F. H. Nalder, H. Nalder, C. W. S. Crawley, and A. Soames. Dated December 28th.

24,979. "Improvements in instruments for measuring and recording electric pressures and currents." W. Thonson (Baron Kelvin). Dated December 29th.

25,009. "Electric heater and its application to electric cigar lighters." F. W. Schinder. Dated December 29th.

25,013. "Improvements in or connected with apparatus for feeding carbons in electric arc lamps." F. Hallows and F. J. Beaumont. Dated December 29th.

25,016. "An improved rosette for electric wires." H. H. Lake. (Communicated by W. B. Rand, United States.) Dated December 29th.

25,056. "Improvements in incandescent electric lamps." F. Lyst. Dated December 30th.

25,082. "Improved means for arranging and intensifying the magnetic fields of dynamo-electric machinery. J. W. T. Cadett. Dated December 30th.

25,086. "Improvements in the construction of steam turbines." J. S. Raworth. Dated December 30th.

25,090. "Improvements in the regulation and expansion of steam in steam turbines." J. S. Raworth. Dated December 30th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1892.

18,066. "Improvements in electric meters." F. W. Golby. (Communicated by J. A. Dejardin, Paris.) Dated October 10th. Is based upon the principle of "Joule's electro-dynamometer" wherein the movements of a bobbin are conveyed to a scale beam, carrying on one side of its fulcrum a weight or mass, and on the other side a scale pan, the rod of the movable bobbin being connected to the beam between the scale pan and the fulcrum. 1 claim.

18,700. "Improvements in electrical ceiling roses." T. G. Poole and Woodhouse & Rawson Utd., Ltd. Dated October 19th. Consists in forming an additional groove round the circumference of the pillar, in such a position near to its top, that an elastic ring of any suitable material may be sprung into it outside the lead wires, holding them tightly in position, and on screwing down the cover the ring is further compressed and forms a joint to the cover; in this way any wear and tear there may be is borne by the said elastic ring and not by the insulating covering of the lead wires. 1 claim.

19,393. "Improvements in electric battery apparatus." T. Froggatt. Dated October 28th. Has for its object to so construct the containing apparatus of electric batteries in which liquid is used in the cells, as to prevent such liquid escaping whilst at the same time permitting the gases to escape, and thereby facilitate the construction of batteries capable of being safely transported on the person, in the pocket, or otherwise, avoiding leakage of liquid. The inventor provides a suitable outlet tube from each cell into an outer chamber and so as to project thereinto and within a semi-spherical or other suitably shaped chamber, within the second chamber and closed therefrom except by a pin hole, or pin holes, or tube with pin hole or holes. From the secondary or intercepting chamber proceeds another tube, or tubes projecting inwards and outwards of the outer casing of the secondary chamber to give vent to the escaping gases. 2 claims.

19,729. "Improvements in, and means or apparatus for rectifying alternating currents for working continuous current motors, and for electrolytical purposes." C. Pollak. Dated November 2nd. Has for object to substitute for converters or transforming devices a simple commutating apparatus which will convert the alternating current into a pulsating or intermittent (continuous direction) current, in such a manner that the regular oscillations of the current strength and of the tension can be reduced to any desired small amount. 7 claims.

19,959. "Improvements in the means or apparatus for measuring electricity." E. H. P. Humphreys and W. Friese-Greene. Dated November 5th. Has reference to the measurement of electricity and specially to measuring the aggregate amount of electric current which has flowed through a given circuit at a constant voltage or pressure. 5 claims.

20,488. "Improvements in apparatus for closing an electric circuit by the passage of a locomotive or train over a line of railway, and recording apparatus connected therewith." F. W. Webb and A. M. Thompson. Dated November 12th. Relates to an improved arrangement of rail contact actuated by the deflection of the rails. 2 claims.

20,598. "Improvements in and relating to the manufacture of electric accumulators." C. Theryc and A. Oblasser. Dated November 14th. The electrodes of the improved accumulator are surrounded by a perforated envelope, sheath, or wrapper, of an insulating material or non-conductor of electricity, composed of flexible, or preferably rigid, sheets of celluloid, India-rubber, ebonite, gutta-percha, filbrolithoid, vulcanised fibre or other compound constituted by the same or other materials which are sufficiently good insulators. 3 claims.

20,610. "Improvements in telephone circuits." G. L. Anders and W. Kottgen. Dated November 15th. Consists in providing one induction coil and one battery only for the general use of a number of stations in a given group of telephones. 1 claim.

20,789. "A method of and apparatus for transmitting vocal and other sounds electrically." J. G. Lorrain. (Communicated by C. Clamond, of Paris). Dated November 16th. Consists in varying the length and at the same time the cross section of a conductor forming part of a circuit and constituting a telephonic resistance varier. 3 claims.

21,372. "Improvements in insulators for electric telegraph wires and other electric conductors." B. A. J. ESPEUT. Dated November 23rd. Claim:—The combination of parts substantially as described consisting of an insulator, two metal staples made fast in the crown thereof on each side of the conductor and a key or wedge passing through the staples and locking the conductor fast between them and the surface of the insulator.

21,376. "Improvements in electrical resistances." H. EDMUNDS. Dated November 23rd. Consists in making the resistant metal or material, plaited, knitted, woven or otherwise formed with interstices, which will cause a comparatively large surface of the metal or material to be presented to the air. 1 claim.

21,377. "Improvements in electric conductors." H. EDMUNDS. Dated November 23rd. The inventor forms a tubular conductor by plaiting, or otherwise interlacing, or combining wires into the form of a tube. 1 claim.

21,602. "Operating electric meters from a central position in such a way that charge for the current can be varied according to the time of day." W. H. SCOTT. Dated November 26th. The inventor connects up each meter by means of a system of special meter wires to the central station or other central position, the meters being of the kind that are made to integrate periodically the current being used, by means of small periodic currents sent from the central position which either react on the main current being used by the consumer as in the meter Patent No. 16,623, 1888, and 19,525, 1889, or which operate separate mechanism which effects the integration of the currents flowing at the different times. The small periodic currents he sends by means of clockwork with suitably arranged contacts, which at certain intervals make contact with some convenient source of electricity so that the number of periodic currents per hour that are sent into the meter can be reduced at certain hours of the day. 4 claims.

22,038. "Improvements in and relating to stands for incandescent electric lamps." J. CATHREIN. Dated December 1st. A lead carrier provided on the lamp frame is made of such a length that, together with the height of this frame and the table or the like upon which the stand may be put, it extends beyond the ordinary height of a man. One end of the flexible lead is connected with the main conductor at a point situated in the middle of the ceiling. The lead has such a length, that when stretched it will reach to a point which is at the greatest distance from the point of attachment in the middle of the ceiling. 3 claims.

22,187. "Improvements in lightning arresters." R. BELFIELD. (Communicated from abroad by the Westinghouse Electric and Manufacturing Company, of Pittsburg.) Dated December 3rd. Claim:—A lightning arrester consisting of two or more adjacent pieces of metals or alloys which are incapable of forming or maintaining an electric arc, one of the pieces being connected to an electric main and another of the pieces being connected to earth, substantially as described.

22,473. "Improvements in dynamo-electric machines." C. E. L. BROWN. Dated December 7th. Has reference to improvements in dynamo-electric machines of the alternating current type. 6 claims.

22,719. "Improvements in street boxes used in the underground distribution of electricity." W. GEIPEL. Dated December 10th. Claim:—The herein described method of making a street box of two or more metal parts telescoping into each other so as to be easily adjusted to suit the level of the street, and packed with cement or other substance, substantially as described.

23,007. "Improvements in galvanic batteries." W. WALKER and F. R. WILKINS. Dated December 14th. Consists in arranging the carbon element that while one side is exposed to the action of the electrolyte, the other side of the carbon is exposed to the atmosphere so that the hydrogen formed on the inside of the carbon (that is the side exposed to the electrolyte) combines with the oxygen of the atmosphere through the pores of the carbon and prevents polarisation. 2 claims.

23,054. "Improvements in medical and other electric induction coils." J. W. DAVIS. Dated December 15th. Consists chiefly of a rubber pad, or cushion, placed on the hammer, or hammers, of the contact breaker of such coil, or upon the end of the magnet facing to the hammer or hammers of the contact breaker, or upon both; in such a manner that when an electric current is passed through the coil the contact breaker vibrates in the usual way, but the noise produced by the working of the coil is thereby greatly lessened. 3 claims.

23,113. "Apparatus for determining differences between the phases of two electric alternating currents of like number of alternations, applicable also to the regulation of alternating current dynamos." M. VON DOLIVO-DOBROWOLSKY, and the company ALLGEMEINE ELEKTRICITATS-GESELLSCHAFT. Dated December 15th. Relates to an apparatus which allows of the detection and measurement of any difference that may occur between the phases of two electric alternating currents of like number of alternations. The invention also comprises a special arrangement whereby the said apparatus will show and measure any lag or advance that may have taken place between the phases of the current furnished by an alternating current dynamo, or alternator, and those of the electromotive force, or pressure, of this current, and, finally, an arrangement by means of which the said apparatus is caused to correct automatically the said difference between the current and pressure phases. 3 claims.

23,290. "Improvements in alternate current motors for single and polyphase electric currents." E. ARNOLD. Dated December 17th. Relates more particularly to the winding of the armature. 7 claims.

23,539. "Improvements in or in connection with dynamo-electric machinery." W. L. SPENCE and D. STEWART & CO., LTD. Dated December 21st. In order to minimise as far as possible the effect of cross magnetisation by the armature, we adopt an iron-clad form of field in which the exciting coils are radial and which are partially wound over and thus directly magnetise the armature. Radial pole-pieces project inwardly and surround the armature on the two end faces and on the periphery. The yoke completing the magnetic circuit has an approximately rectangular box section, it encloses the whole of the machine and supports the bearings at each end. 4 claims.

23,579. "Improvements in electric incandescent lamps." A. ZOBEL and F. BUCHMULLER. Dated December 21st. Claim:—An incandescent lamp with two or more incandescent filaments, the latter capable of being made incandescent singly or together, the interpolation of the supplementary filament or filaments being effected by addition of a third wire standing out of the lamp, or by providing on the conduction wire a movable plate or wire of hook, fork, or any other suitable form, so arranged as to leave its insulated position and effect the contact when an appropriate movement is given to the lamp, substantially as described.

23,658. "Improvements in the armouring, covering, or protecting of electrical cables and the like." H. EDMUNDS. Dated December 22nd. Consists in providing strips of thin and flat metal which are applied by plaiting in a suitable plaiting machine, the flat strips allowing of the plaited armouring or covering being very efficiently applied to either round or flat conductors or cables. 3 claims.

23,675. "Improvements in the construction and arrangement of switches for use in connection with electric generators, especially applicable to alternators and their exciters." J. S. RAWORTH. Dated December 22nd. The inventor employs a switch so constructed that it can only be closed when the difference of potential at the terminals of the exciter is approximately the same as that in the main exciting conductors, and that it will automatically break the current whenever, from any cause, the exciter may cease to transmit current to the said mains. 6 claims.

23,892. "Improvements in multiple telephony." M. HUTIN and M. LEBLANC. Dated December 27th.

23,902. "Improvements in alternate current motors." C. E. L. BROWN. Dated December 27th. Relates to improvements in alternate current motors whereby such motors can be worked with non-synchronous currents, or non-synchronously and without collectors or sliding contacts; that is, similarly to motors for multiphase currents. 3 claims.

24,098. "Method of and apparatus for starting non-synchronous single phase alternating current motors." C. E. L. BROWN. Dated December 30th. Consists in destroying the equilibrium of the forces set up between the inducing and induced parts of the motor when the current is switched on whilst the motor is at rest. For this purpose the motor may be constructed with double windings, in such a way that besides that always required for the motor, a second winding of greater or less self-induction is employed, which in a two-pole arrangement is placed at an angle of 90° from the first one. By this means, when the windings are placed in circuit with an alternating current generator, a rotary field is produced, which overcomes the neutral state and causes the rotary portion of the motor to start. 5 claims.

24,127. "Improvements in secondary batteries." F. KING. Dated December 31st. The inventor provides the plates (preferably the pure or spongy lead plates or plates of like denomination) with ribs, pins, or the like, projecting from the surface of the plate a distance slightly less than the distance apart at which the plates are to be maintained. At the outermost face or edge of each of the said projecting ribs or line or row of pins or the like, he places a piece or strip of insulating and acid resisting substance, which is held in position against the opposing plate by the said ribs or pins or the like, and is preferably so shaped as to deflect away from the rib, pin, or the like, any material resulting from the exfoliation of the surface of the opposing plates or any particles of material which may fall out of the said plates. 1 claim.

1893.

9,779. "Electric switches." C. A. ALLISON. (Communicated from abroad by the Electrical Specialty Company, of America.) Dated May 16th. Relates to circuit switches worked by a wheel and ratchet motion. 3 claims.

9,780. "Improved electrical apparatus for obtaining light." F. V. WOOD. Dated May 16th. Relates to an apparatus which enables a small spirit lamp to be lighted electrically, same serving either for the purpose of showing a small light or for igniting cigars.

10,205. "Electric steering gear." F. L. DYER and L. H. DYER. Dated May 23rd. An electric motor is attached to the valves of the steering engine, so that when the electric motor moves in one direction, the steering engine will be moved in the same direction, and when the electric motor moves to a certain extent of movement, the steering engine will move to a certain extent of movement. The electric motor is connected by insulated wires to a controlling device in the pilot house, so that when the steersman desires to steer the vessel to port, he will move this controlling device in a given direction, and to a certain extent of movement, which will control both the direction and extent of movement of the electric motor, and that electric motor, in its turn, will control the direction and extent of movement of the steering engine. 10 claims.

11,106. "Improvements in electrolytic cells." T. CRANEY. Dated June 6th. Consists in a combined carbon anode and electrolytic diaphragm. 3 claims.